THE
371A

PROGRAMMABLE
HIGH POWER
CURVE TRACER

SONY.
Tektronix

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ABOUT THIS MANUAL

This manual provides information that enables you to effectively and efficiently use the measurement features of the 371A. Information is presented in an order in which you can quickly learn measurement concepts and begin applying the 371A to a particular measurement application. Information is presented as follows:

Chapter 1: General Information provides general information about the 371A. It lists product accessories and options and concludes with a description of measurement concepts and related manuals.

Chapter 2: General Operation provides a general overview of 371A operation.

Chapter 3: Exercises provides a series of operational and measurement procedures that

* Exercise front panel controls, indicators and product features. Use this procedure as a training exercise and as a general product verification procedure following initial installation of the 371A.

* Demonstrate how to make specific semiconductor measurements. These procedures can also be used as training exercises.

NOTE

It is not practical to provide procedures that demonstrate all the features and capabilities of the 371A. We have provided a range of procedures that best demonstrate the power, capability and functionality of the 371A. When you perform the complete set of procedures, you will gain an appreciation for the power, utility, and operational concepts of the 371A. You can then build on this understanding by reading and applying the information contained in the other chapters and appendices of this manual.

Chapter 4: Controls, Indicators, and Connectors provides a detailed explanation of all front and rear panel controls, indicators and connectors. Use this section as a reference when you need to know the full functions of a specific control, indicator, or connector.

Chapter 5: GPIB provides a detailed reference for the General Purpose Interface Bus. It not only reviews GPIB principles, but also summarizes the GPIB interfacing capabilities and explains how to configure and control the 371A in a GPIB system.

Appendix A: Specifications provides a complete list of 371A characteristics and specifications.

Appendix B: Diagnostics provides a description of 371A power-up diagnostics.

Appendix C: Messages provides a complete listing of displayed messages.

Appendix D: Installation and Repacking provides instructions for unpacking, installing, and repacking the 371A for shipment.

MANUAL CONVENTIONS

This manual uses the following conventions:

- 371A refers to the SONY/Tektronix 371A High Power Curve Tracer

- DUT refers to the device under test

- In the text when you see a word such as STORE it represents a knob, button, indicator, or connector on the 371A.

- In the text when you see a word string such as CHECKSUM ERROR it represents a message displayed on the 371A screen.

- In the text when you see a word such as ENTer it represents a GPIB command.

- In the text when you see a word such as ENTer? it represents a GPIB command query.

- In the text when you see <ascii character string>, accompanying text describes the meaning of the ascii character string.

RECOMMENDED LEARNING PATH

The following is a recommended learning path for the curve tracer user.

1. Familiarize yourself with the contents of this manual before beginning device testing. Especially take time to read the contents of Chapter 1: General Information and Chapter 2: General Operation.

2. Power up the 371A and note the power-up indications as described in "Powering up the 371A and Storing Power-Up Default Settings" in Chapter 3: Exercises.

3. After a successful power-up, perform the remaining "First Time Operating Exercises" provided in Chapter 3: Exercises.

4. Now you are ready to use the 371A to make semiconductor measurements. Continue with the "Measurement Exercises" in Chapter 3: Exercises, per your application.

5. To learn more about the 371A controls, indicators and connectors, read the descriptions in Chapter 4: Controls, Indicators, and Connectors.

6. To learn how to use the 371A as a GPIB instrument for program development, system control, data processing, and data storage, refer to Chapter 5: GPIB.

Safety Warning

SAFETY TERMS

The following terms may be found in this manual or printed on the 371A and its accessories.

In this manual:

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CAUTION
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Caution statements identify conditions or practices that could result in damage to the equipment or other property

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WARNING
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Warning statements identify conditions or practices that could result in personal injury or loss of life.

As marked on equipment:

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as on reads the marking.

SYMBOLS

The following symbols may be found on the 371A and its accessories.

⚡ DANGER–High Voltage

⏚ Protective ground (earth) potential

⚠ ATTENTION–Refer to manual

⌐ WARNING ⌐

This instrument operates from a single-phase power source and has a detachable three-wire power cord with a two-pole, three-terminal grounding-type plug. The voltage to ground (earth) from either pole of the power source must not exceed the maximum rated operating voltage 250 Volts rms).

Before making connection to the power source, make sure that the instrument is set for the power source voltage and is equipped with a two-pole, three-terminal, grounding-type plug.

This instrument is Safety Class 1 equipment (IEC1) designation). All accessible conductive parts are directly connected through the grounding conductor of the power cord to the grounding contact of the power plug. Therefore, the power plug must only be inserted in a mating receptacle with a grounding contact. Do not defeat the grounding connection. Any interruption of the grounding connection can create an electrical shock hazard.

For electric shock protection, connect the instrument to ground before connecting to the instrument input or output terminals.

The 371A provides output voltages up to 3 kV, which can be dangerous if the device under test is connected directly to the test fixture connector on the 371A, without using the fixture unit.

Do not disable the safety interlock and then attempt to operate the 371A. You may accidently contact high voltage and serious personal injury or death may result.

Prolonged use of the 371A at high power settings can make the protective cover hot enough to cause injury. Avoid touching the protective cover or any of the items enclosed under the cover until they have cooled.

CAUTION

To prevent damage to the instrument, always check the settings of the LINE VOLTAGE indicator on the rear panel of the 371A before connecting the instrument to the power source. If the indicated setting differs from the available line voltage, refer a qualified service technician to the 371A Service manual for verification of power supply configuration.

Prolonged use of the 371A can cause high temperatures which may damage the instrument or device under test. When applying current in the 3 KW range, test time should be limited to four minutes, followed by at least 11 minutes of cooling.

To prevent equipment damage, do not short together the collector and emitter terminals of the test adapters.
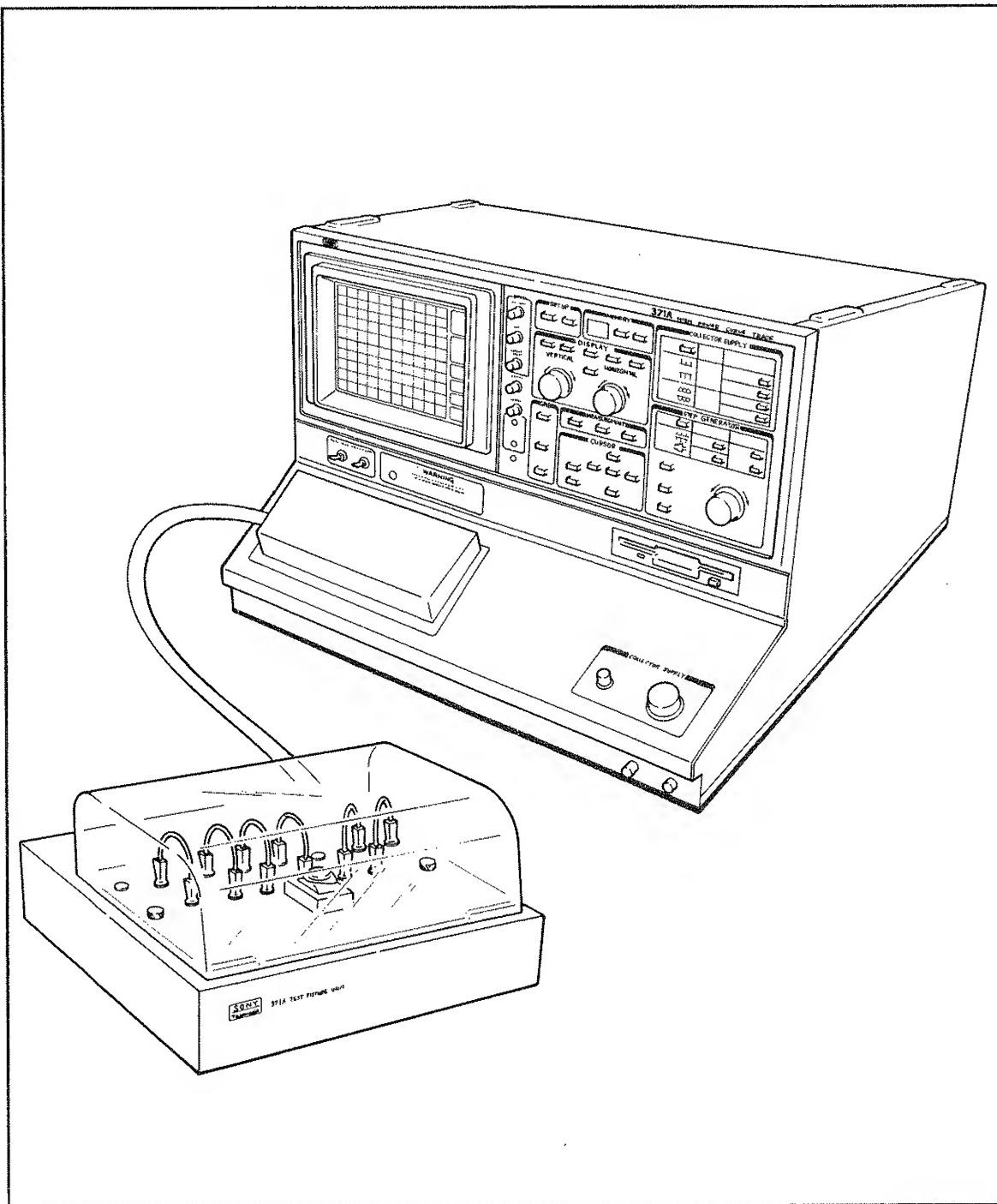
371A main unit and test fixture unit.

Chapter 1
GENERAL INFORMATION

The SONY/Tektronix 371A High Power Curve Tracer provides both high current and high voltage for testing high-power semiconductor devices at user-selected power settings. It can test devices at up to 400 amps at power levels up to 3000 watts. By measuring and displaying the characteristics on a CRT screen, the 371A enables a user to analyze and evaluate the static characteristics of semiconductor devices.

FEATURES AND CAPABILITIES

Features and front panel operation are similar to earlier SONY/Tektronix curve tracers, thus if you are already acquainted with the SONY/Tektronix curve tracer family, you do not have to learn a new set of knobs and buttons.

Non-volatile memory (RAM) and floppy disk storage enable you to store frequently used test setups and curve characteristics for quick and easy measurement comparisons. Using memory in this way helps you avoid errors associated with manual testing, and allows you to run more repetitive-type tests in any given period. You can store up to 64 characteristic curves and 64 setups on a floppy disk, and up to 16 characteristic curves and 16 setups in non-volatile memory. Stored characteristic curves and setups can be recalled for additional analysis and comparison.

The 371A provides direct readout on the CRT of offset base/gate voltage or current. The 371A calculates these values for you, unlike earlier curve tracers where these functions had to be calculated manually.

The 371A also has the ability to average readings to reduce the effects of random noise, which can obscure actual curve data.

The rear panel contains two GPIB connectors. A plotter interface connector allows easy connection to a GPIB-compatible plotter for direct screen dump capability. No controller is needed. The plotter connects directly to the 371A, and allows you to use the 371A for other tasks while a copy is in process.

A second GPIB connector is for use by a GPIB-compatible controller or other GPIB instrumentation. Using this connector and appropriate GPIB instruments, you can create and control tests to suit your application. A typical GPIB system will include a controller and one or more instruments, such as the 371A, a signal generator, a digital multimeter, and a digital oscilloscope. Some GPIB instruments are talk only or listen only devices while

others can both talk and listen. The 371A does both. Linking a controller to the 371A, and possibly other instruments, provides operation in four major task areas:

* program development
* system control
* data processing
* display and storage

A complete GPIB reference is provided in Chapter 5: GPIB of this manual.

PRODUCT ACCESSORIES AND OPTIONS

The following is a list of standard accessories shipped with each 371A.

Accessory	Tektronix Part Number
Test Fixture Unit	016-0908-02
Wire Set: patch cords and alligator clips (6 each)	012-1371-00
Operators Manual	070-8043-00
Fuses:	
250 V, 1 A, slow blow	159-0022-01
250 V, 2 A, slow blow	159-0238-00
250 V, 4 A, slow blow	159-0291-00
Floppy Disk (double density)	119-3446-00
Power Cord	See "Power Cord Options" later in this chapter for the part number of applicable cord
Test Adapters:	
In-Line Adapter	A1002
TO-3/TO-66 Adapter	A1003

These accessories are provided with your 371A at time of purchase and are subject to change. Check the accessories package when you receive your 371A for the most current list of standard product accessories.

OPTIONAL ACCESSORIES

The following optional accessories are available through your Tektronix field office representative.

Optional Accessory	Tektronix Part Number
Service Manual	070-8044-00
Field Wiring Cable	198-5628-00
GPIB Cable	012-0991-00
Test Adapters:	
Blank Adapter	A1001
Offset Lead/Power Adapter	A1004
Axial Lead Adapter	A1005
Camera Adapter, C59AP	016-0249-06
Camera Adapter, C5C, Opt 01	016-0357-01
Camera Adapter, C4, Opt 02	016-0357-01

Contact you nearest Tektronix field representative for an up-to-date list of 371A optional accessories.

POWER CORD OPTIONS

Table 1-1 lists the various 371A power cord options and their respective plug configurations.

Table 1-1
Instrument Power Options

Option Number	Plug Configuration	Usage	Nominal AC Line Voltage	Reference Standard
Standard		North American 120 V/15 A	120 V	ANSI[1] C73.11 NEMA[2] 5-15-P IEC[3] 83
A1		Universal European	240 V	CEE[4] (7), II, IV,VII IEC 83
A2		UK	240 V	BSI[5] 1363 IEC 83
A3		Australia	240 V	AS[6] C112
A4		North American 240 V/15A	240 V	ANSI C73.20 NEMA 6-15-P IEC 83
A5		Switzerland	220 V	SEV[7]
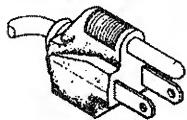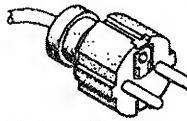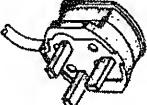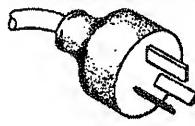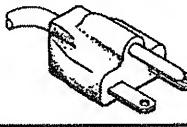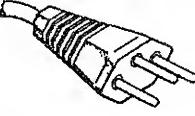
[1]ANSI   - American National Standards Institute
[2]NEMA   - National Electrical Manufacturer's Association
[3]IEC   - International Electrotechnical Commission
[4]CEE   - International Commission on Rules for the Approval of Electrical Equipment
[5]BSI   - British Standards Institute
[6]AS   - Standards Association of Australia
[7]SEV   - Schweizevischer Elektrotechischer Verein

IBM-PC UTILITY SOFTWARE

This optional utility software package expands the versatility of the 371A by coupling it with IBM-compatible controllers. This software lets you save front-panel settings to mass storage for later retrieval, saving valuable time when performing multiple tasks. Semiconductor device curves can also be saved to disk and exported to files for use with popular analysis programs such as Lotus 1 2 3®.

This utility software is menu driven for ease of use, and includes an easy-to-use test program language called Test Script. Using Test Script, you can create tests to automatically measure and log results to a disk file. The log files may be printed for convenient analysis. Sample test scripts are included which can be modified to make a broad range of measurements.

Contact your nearest Tektronix representative to order this utility software package.

RACKMOUNT CAPABILITY

The 371A can be mounted in a standard electrical equipment rack using Tektronix-supplied rackmount hardware.

371A COMPONENTS

The 371A consists of two large components: a main unit and a test fixture unit.

Main Unit

The main unit contains front and rear panel controls, indicators and connectors, a display CRT, and the control electronics.

Front and Rear Panels

To use the 371A effectively, you need a clear understanding of the functions and meanings of the operator controls, indicators and connectors mounted on the front and rear panels. Detailed descriptions are provided in Chapter 4: Controls, Indicators, and Connectors.

The CRT functions as the display device. It has 10 x 10 graticule markings etched into its inner surface, the brightness of which can be controlled by the front-panel GRAT ILLUM (graticule illumination) control. A filter mounted on the front of the CRT improves display contrast.

The readout area of the display (which also displays setup information) is divided into two parts:

1. the readout labels which identify the readout information printed in the readout area

2. the readout information which identifies either a specific control setting (such as 1 A or 1 V), or a measured characteristic of the device under test (DUT)

    "Readout Display" in Chapter 4: Controls, Indicators, and Connectors provides a detailed explanation of each readout area.

Readout intensity is controlled by the READOUT/CURSOR knob; label intensity is controlled by the GRAT ILLUM knob.

NOTE

The READOUT/CURSOR control also controls the intensity of other information displayed on the screen, which may include text, messages, and setup and curve identification.

Refer to Chapter 4: Controls, Indicators, and Connectors for a detailed description of this information.

Test Fixture Unit

All tests are made with the semiconductor device mounted inside the test fixture unit. The test fixture unit connects to the front panel of the main unit (as shown in the frontispiece illustration opposite page 1-1).

The test fixture unit contains a patch panel and an adapter panel that are enclosed by a clear plastic cover during the actual testing process. The DUT connects to the patch panel in one of two ways.

1. Using test adapters. Test adapters are used to connect common semiconductor devices to the adapter panel, which in turn is connected to the patch panel using patch cords. This technique is shown in Figure 1-1.

2. Using patch cords. Devices that cannot be connected using test adapters can be connected to the patch panel using patch cords with clips. In such cases, the adapter panel may have to be removed. Refer to "Connecting a DUT Using Patch Cords" in Chapter 2: General Operation for a description on how to remove the adapter panel.

The test fixture connects to the main unit using the interconnect cable and connector. The top row of connectors on the patch panel are linked internally to the connector cable.

Refer to Chapter 2: General Operation for additional information about the test fixture unit.
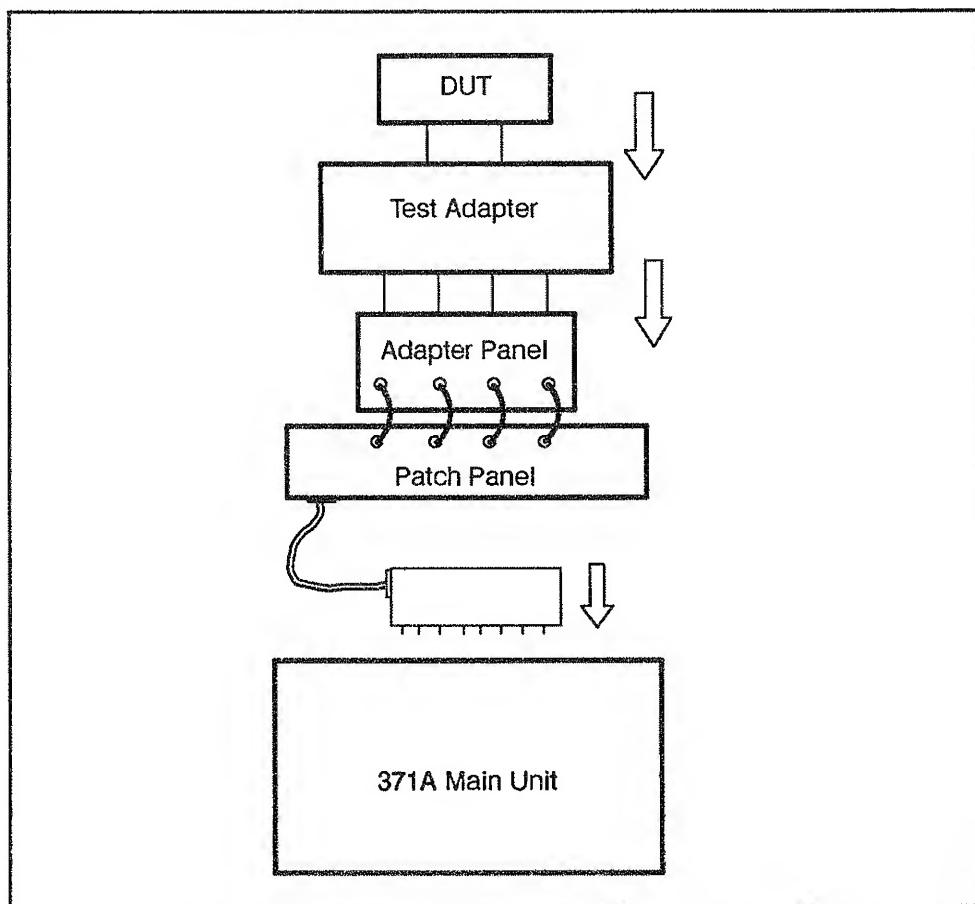
Figure 1-1. DUT connection path when using adapter and patch panels.

Test Fixture Interlock

The test fixture unit is provided with a safety interlock system. Whenever the test fixture cover is in the raised position, the collector supply voltage is disabled and you can safely connect and disconnect devices at the patch panel and the adapter panel. When the cover is closed the collector supply voltage is enabled. The enabled state is indicated by a red WARNING indicator on the 371A. When lit, the WARNING indicator indicates that the collector supply is enabled and that a dangerous voltage may appear at the patch panel terminals on the test fixture unit.

WARNING

Do not disable the safety interlock system and then attempt to operate the 371A. You may accidently contact high voltage and serious personal injury or death may result.

The collector supply is also disabled whenever the test fixture unit cable is disconnected from its connector at the front panel of the main unit.

MEASUREMENT CONCEPTS

The 371A consists of a specially-designed CRT screen and associated electronics that allow a user to display the characteristics of a semiconductor device. The display screen is designed to display the operating characteristics of the DUT in an easy-to-read, standard graph form.

The 371A can be applied to a broad range of semiconductor test application, such as:

* semiconductor design analysis

* semiconductor failure analysis

* incoming inspection of semiconductors

* comparison of semiconductor device characteristics

* semiconductor manufacturing output

Figure 1-2 helps to illustrate 371A measurement concepts. A collector supply and step generator circuits apply voltage or current to the DUT. A detector amplifier measures the resulting effect. Measurement results are displayed on a CRT as one or more characteristic curves.
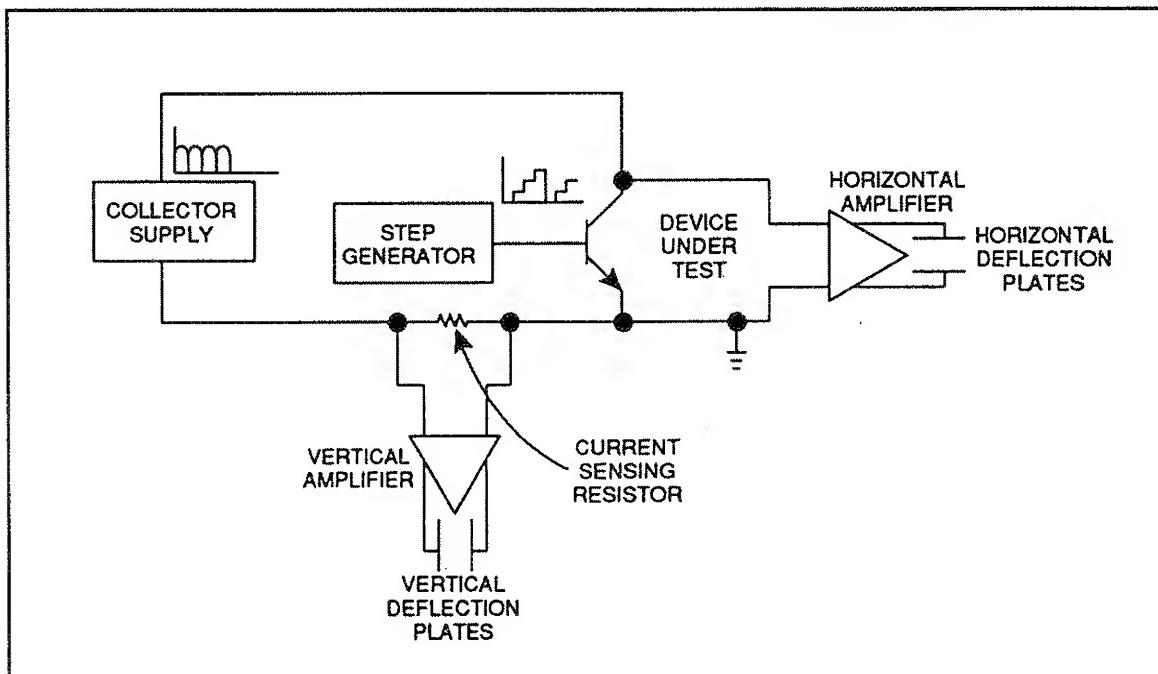
Figure 1-2. Basic 371A block diagram.

Collector Supply

The collector supply provides a swept or pulsed voltage to the DUT. Amplitude is controlled by the collector supply VARIABLE knob. This signal is applied to the collector (drain, anode, or equivalent terminal) of the DUT.

Step Generator

The step generator supplies one voltage or current step, or pulse, for each collector supply sweep or pulse. The amplitude of the voltage or current is set by the STEP/OFFSET AMPLITUDE knob and the number of steps by the NUMBER OF STEPS selection buttons. The signal from the step generator can be applied to the base or emitter (or an equivalent terminal) of the DUT.

Detector Amplifier

The detector amplifiers are connected to the DUT to measure the effect of the stimulus signals from the collector supply and the step generator. The measurement result is amplified and the voltage obtained is applied to the CRT deflection plates. Sensitivity of the amplifier is set by the VERTICAL CURRENT/DIV (vertical current per division) and HORIZONTAL VOLTS/DIV (horizontal volts per division) knobs.

Figure 2-7 shows how memory is structured. There are a total of 80 memory locations for storing characteristic curves and 80 memory locations for storing front-panel settings. Non-volatile memory holds 16 characteristic curves and 16 front-panel settings, while the floppy disk holds 64 characteristic curves and 64 front-panel settings. Typically, you would store a characteristic curve and its corresponding front-panel settings in separate memory locations of the same number.
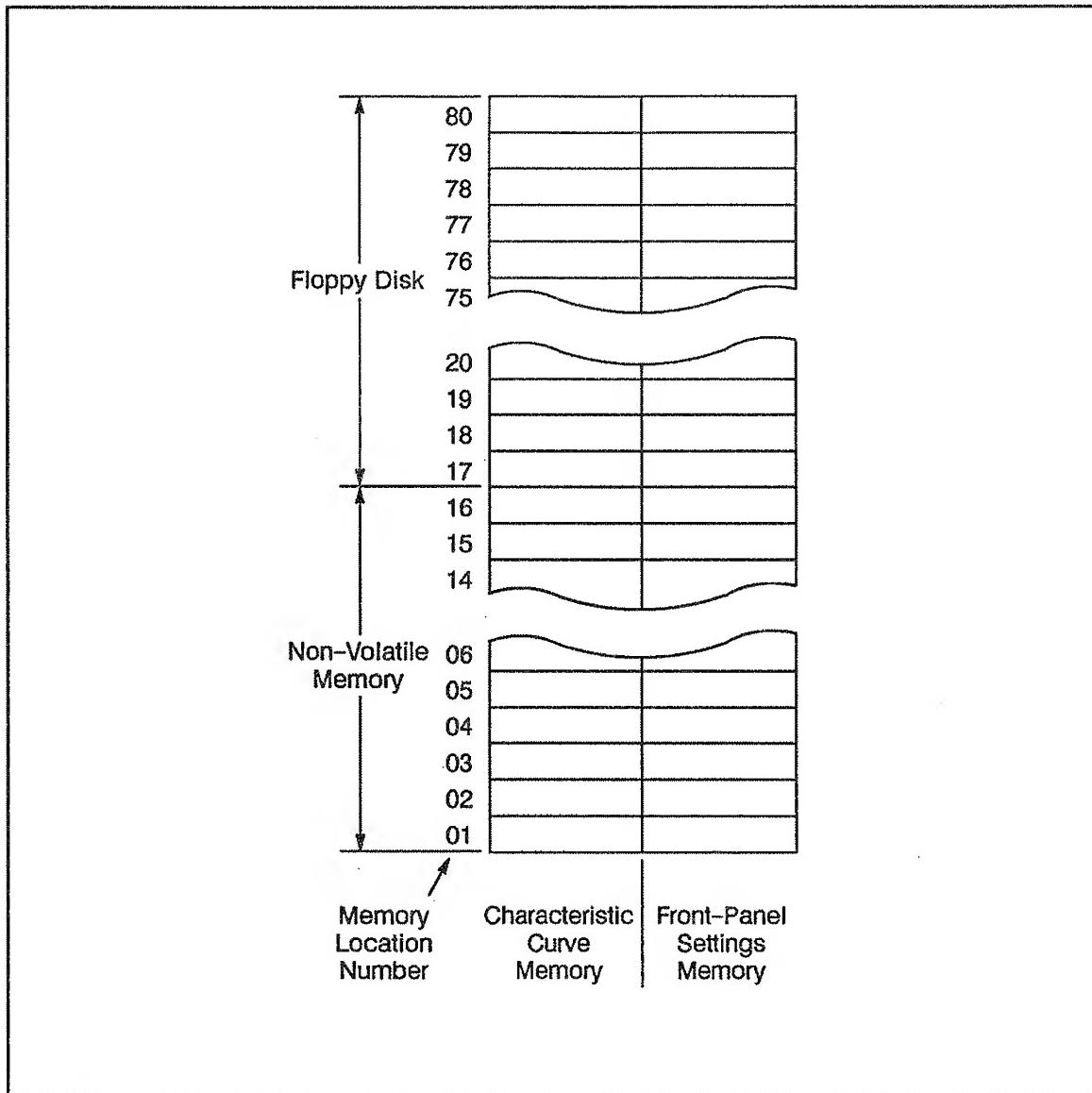
Figure 2-7. 371A memory structure.

The following information describes how to

• use the file directory

• select a memory location

• save and recall front panel setting files

• enter and view acquired characteristic curve files

• copy files from non-volatile memory to floppy disk

• copy files from floppy disk to non-volatile memory

• erase non-volatile memory

• transfer data between the 371A and external devices

The File Directory

You can use the file directory features to determine the contents of memory locations.

To display the directory, hold down the cursor SHIFT button and press the RECALL button. A directory similar to the one shown in Figure 2-8 is displayed. Figure 2-8 represents only the first page of the file directory and would be so indicated by the number 1 in the memory LED display. The page title is DIRECTORY – CURVE – and the file directory lists the contents of the first five memory locations for characteristic curves. The word MORE at the bottom of the page means there are more pages to the file directory.
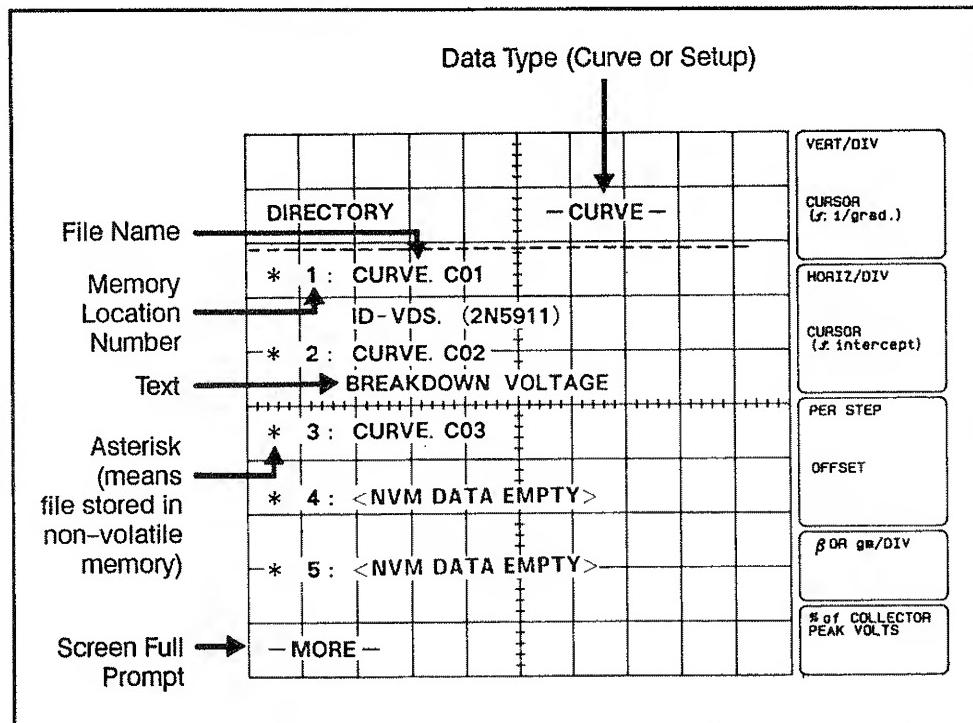
Figure 2-8. Sample directory display.

NOTE

An asterisk before the index number means that the file is stored in non-volatile memory.

To read the second page of the file directory, press the memory up button once. This action displays the number 2 in the memory LED display. The directory page title is changed to DIRECTORY – SETUP – and the file directory lists the contents of the first five memory locations for front panel set-up files. Again, the word MORE at the bottom of the page means there are more pages to the file directory.

You can then sequence through the pages of the file directory as described above, with pages alternating between curve and setup files locations. Use the memory up button to move up in the directory and the memory down button to move down in the directory pages. Odd numbered pages describe memory contents for characteristic curve files; even numbered pages for front-panel setup files.

If there is no data stored in the memory location indicated by the memory location number, a <NVM DATA EMPTY> for locations 1 – 16, and <FD DATA EMPTY> for locations 17 – 80 is displayed in place of the file name. If an attempt is made to display the directory for memory location numbers in the range of 17 – 80 when there is no disk in the disk drive, a <FD NOT READY> is displayed in place of the file name.

When you have sequenced to the last page of the file directory, the word END appears at the bottom left corner of the page.

To reset to page one of the file directory, simultaneously press the memory up and down buttons.

To exit directory display, press any front-panel button or switch other than MEMORY, SAVE, RECALL, or cursor SHIFT.

Select A Memory Location

The memory up and down buttons are used to select a memory location (01 to 80) in which to save or read a curve or setup file. The memory location number is displayed in the LED readout to the left of the memory down button.

Data is directed to be read to or from a selected memory location depending on which front-panel button you press.

Save and Recall Front Panel Setting Files

Saving front panel settings enables you to store desired setups for use at some future time. Once saved, you can retrieve (recall) the file to quickly preset the front-panel controls to settings defined by the file.

The setup SAVE and RECALL buttons allow you to save or recall a group of front panel settings. All of the front panel settings except those listed in Table 2-6 can be stored in and recalled from memory.

Table 2-6
Controls That Cannot Be Stored In Mass Storage

Control Group	Specific Control
Collector Supply	LOOPING COMPENSATION
DISPLAY	ENTER
Setup	RECALL, SAVE
Memory Location	Memory location buttons
CRT Controls	INTENSITY, FOCUS, GRAT ILLUM, POSITION TRACE ROTATION
GPIB	RESET TO LOCAL, PLOT, CURVE

To save front-panel settings, select the desired memory location number, then press the SAVE button. The front panel settings, along with any user-entered text, are saved at the selected memory location number.

┌─────────────┐
│ *CAUTION* │
└─────────────┘

Saving to a memory location overwrites with new data. Therefore, before saving a file to a memory location, check the memory location using the file directory feature. Make sure that the memory location does not contain a setup file that you may need.

To recall a file containing front-panel settings, select the desired memory location number, then press the RECALL button.

NOTE

If the position of the collector supply HIGH VOLTAGE breaker and HIGH CURRENT breaker is not the same as when the front-panel settings were originally saved, the message H.V. UNMATCH, *or* H.C., UNMATCH, *or* H.V./C. UNMATCH *is displayed. You must switch the unmatched breaker, and press the RECALL button once again.*

To save the sweep mode setting, press the SAVE button. The final value of the collector supply or step generator output is also stored.

Enter and View Acquired Characteristic Curve Files

To enter (save) an acquired characteristic curve when operating in store, view, or sweep modes, select the desired memory location number, then press the ENTER button. Display settings, readout values, and displayed text are also saved. (Refer to "Setup Controls," in Chapter 4: Controls, Indicators and Connectors for a list of information that cannot be stored in mass storage. Refer to "Display Modes" description earlier in this chapter for additional details regarding saving of characteristic curves when operating in specific display modes.)

To view (read) a characteristic curve and associated information from a memory location, select the desired memory location number, then press the VIEW button.

Copying Files from Floppy Disk to Non-Volatile Memory

The 371A allows you to copy simultaneously up to 16 characteristic curves and up to 16 front-panel setups from floppy disk to non-volatile memory. You are able to perform tests more quickly when working files are being read from non-volatile memory rather than from directly from the floppy disk.

The following example describes how you would use this feature:

1. Select the floppy disk memory location number from which you wish to begin copying to non-volatile memory. For example, if you select memory location 24, index locations 24-39 will be copied to memory locations 1-16, respectively.

2. Hold down the cursor SHIFT button and then press the SINGLE button.

   Observe that the message PRESS SINGLE floppy -> NVM is displayed for about five seconds.

3. Press the SINGLE button once again while the message PRESS SINGLE Floppy -> NVM is displayed. (Failure to do so within about five seconds causes the message COPY CANCELED to be displayed and the copying function is canceled.)

Copying occurs by first copying all 16 characteristic curve locations and then copying all 16 front-panel setup locations.

Curve data is read from the specified memory location (location 24, in this example) and copied to non-volatile memory location 1, then from index location 25 to memory location 2, and so on. Copying of curve data is terminated when all 16 curves are copied from floppy disk to non-volatile memory. If non-volatile memory contains less than 16 stored curves, or memory location 80 is reached before 16 curves are copied, curve copying is completed when the last stored curve is copied to floppy disk.

When curve copying is completed, the 371A begins copying front-panel setups following the same sequence as for curves.

During the copy process, the number displayed by the memory LED display indicates the memory location to which the curve or front-panel setup is being copied.

Copying Files from Non-Volatile Memory to Floppy Disk

The 371A allows you to simultaneously copy up to 16 characteristic curves and up to 16 front-panel setups from non-volatile memory to the floppy disk.

The following example describes how you would use this feature:

1. Select the floppy disk memory location number to which you wish to copy the non-volatile memory contents. For example, if you select location 24, memory contents will be copied to memory locations 24-39.

2. Hold down the cursor SHIFT button and then press the REPEAT button.

    Observe that the message PRESS REPEAT NVM -> Floppy is displayed for about five seconds.

3. Press the REPEAT button once again while the message PRESS REPEAT NVM -> Floppy is displayed. (Failure to do so within about five seconds causes the message COPY CANCELED to be displayed and the copying function is canceled.)

Copying occurs by first copying all 16 characteristic curve locations and then copying all 16 front-panel setup locations.

Curve data is read from index location 1 and copied to the specified index location (index 24, in this example), then from index location 2 to index location 25, and so on. Copying of curve data is terminated when all 16 curves are copied from non-volatile memory to floppy disk. If non-volatile memory contains less than 16 stored curves, or index location 80 is reached before 16 curves are copied, curve copying is completed when the last stored curve is copied to floppy disk.

When curve copying is completed, the 371A begins copying front-panel setups following the same sequence as for curves.

During the copy process, the number displayed by the memory LED display indicates the memory location to which the curve or front-panel setup is being copied.

Erasing Non-Volatile Memory

To erase all data stored in non-volatile memory, hold down the cursor SHIFT button then press the display INVERT button. The message PRESS INVERT is displayed for about five seconds. Immediately press the INVERT button again before the message PRESS INVERT disappears from the display screen (you have about five seconds). If the INVERT button is not pressed during the time the message PRESS INVERT is displayed, the formatting function is aborted (the message ERASE CANCELED is displayed) and the 371A returns to normal operating mode.

Data Transfer with External Devices

You can transfer data files between the 371A and external devices via the General Purpose Interface Bus (GPIB). Refer to Chapter 5: GPIB for detailed information regarding GPIB functions.

DISK FORMATTING

A floppy disk must be formatted before it can be used in the 371A. (Files are compatible with MS-DOS.) A "371A" volume label is written and a "371A" sub-directory is made on the disk formatted on the 371A. For a description of how data is formatted, refer to the CURve? query command in Chapter 5: GPIB.

NOTE

If you attempt to format a disk with the write protect tab set at the write protect position, the message WRITE PROTECT *appears at the bottom of the CRT, and the formatting function is canceled.*

To format a disk, insert the disk into the disk drive. Then while holding down the cursor SHIFT button, press the SAVE/FORMAT button. The message PRESS SAVE is displayed for

about five seconds. Immediately press the SAVE button again before the message PRESS SAVE disappears from the display screen. (You have about five seconds.) If the SAVE button is not pressed during the time the message PRESS SAVE is displayed, the formatting function is aborted (the message FORMAT ABORTED is displayed) and the 371A returns to normal operating mode.

While disk formatting is in progress, the message NOW FORMATTING is displayed at the bottom left of the display screen and the number of the track currently being formatted is displayed in the memory index display. When the track number reaches 79, formatting is completed, the message DISK FORMATTED is displayed, and the 371A returns to the preselected operating mode.

FLOPPY DISK HANDLING

The 3.5 inch (double-density) floppy disks are easy to handle and store. However, observe the following precautions to protect the disk and the integrity of the stored data.

> CAUTION

Do not expose the floppy disks to strong magnetic fields, and do not place them near strongly ferromagnetic material that can be easily magnetized. If these cautions are not observed, data may be destroyed, or errors may occur.

Do not expose floppy disks to direct sunlight or high temperatures for long periods of time. Also, avoid storing floppy disk in extremely cold or humid environments. Prolonged exposure to such environmental conditions will damage floppy disks.

It is important to place the floppy disks back in their cases for long-term storage to avoid prolonged exposure to dust and other contaminants.

371A INTERFACE

The 371A has two interface connectors: an HPGL-compatible plotter connector and a General Purpose Interface Bus (GPIB) connector for interconnecting self-contained instruments, controllers, and other devices. Refer to Appendix D: Installing and Repacking for additional information on plotter connection and interfacing.

Plotter Interface

Most HPGL-compatible plotters with an input buffer of at least 8K can be connected to the PLOTTER INTERFACE PORT on the rear-panel. For such plotters, no controller is needed.

The display can be plotted in two different modes:

1. To plot the entire display: display a characteristic curve, then press the GPIB PLOT button on the front-panel.

2. To plot the characteristic curve only: display a characteristic curve, then while holding down the cursor SHIFT button, press the GPIB PLOT button.

Plotter output begins when the GPIB PLOT button is pressed. To stop output to the plotter, press the GPIB PLOT button once again.

GPIB

Refer to Chapter 5: GPIB for detailed information.

Chapter 2
GENERAL OPERATION

This chapter describes general operating principles of the 371A. Chapter 3: Exercises provides operating and measurement exercises that demonstrate these principles of operation in greater detail. Chapter 4: Control Indicators, and Connectors provides detailed descriptions of all user controls, indicators, and connectors.

The following information leads you through the major operations associated with device measurements in the sequence listed below.

- device connection
- test fixture interlock
- device stimulus
- data acquisition
- measurement modes
- device characteristics display
- display modes
- display cursors
- text editing
- memory and mass storage
- disk formatting
- floppy disk handling
- 371A interfaces

DEVICE CONNECTION

The DUT connects to the 371A via the test fixture unit. All tests are made with the device mounted inside the test fixture unit and its protective cover closed. You can connect the DUT using one of two methods:

1. with the adapter panel and a selected test adapter

2. with patch cords and alligator clips

Connecting a DUT Using the Adapter Panel and a Test Adapter

The adapter panel is mounted inside the test fixture unit and is used with test adapters and patch cords to connect semiconductors with common lead configurations to the 371A. Figure 2-1 shows the connecting links between the DUT and the 371A when using the adapter panel and test adapters.
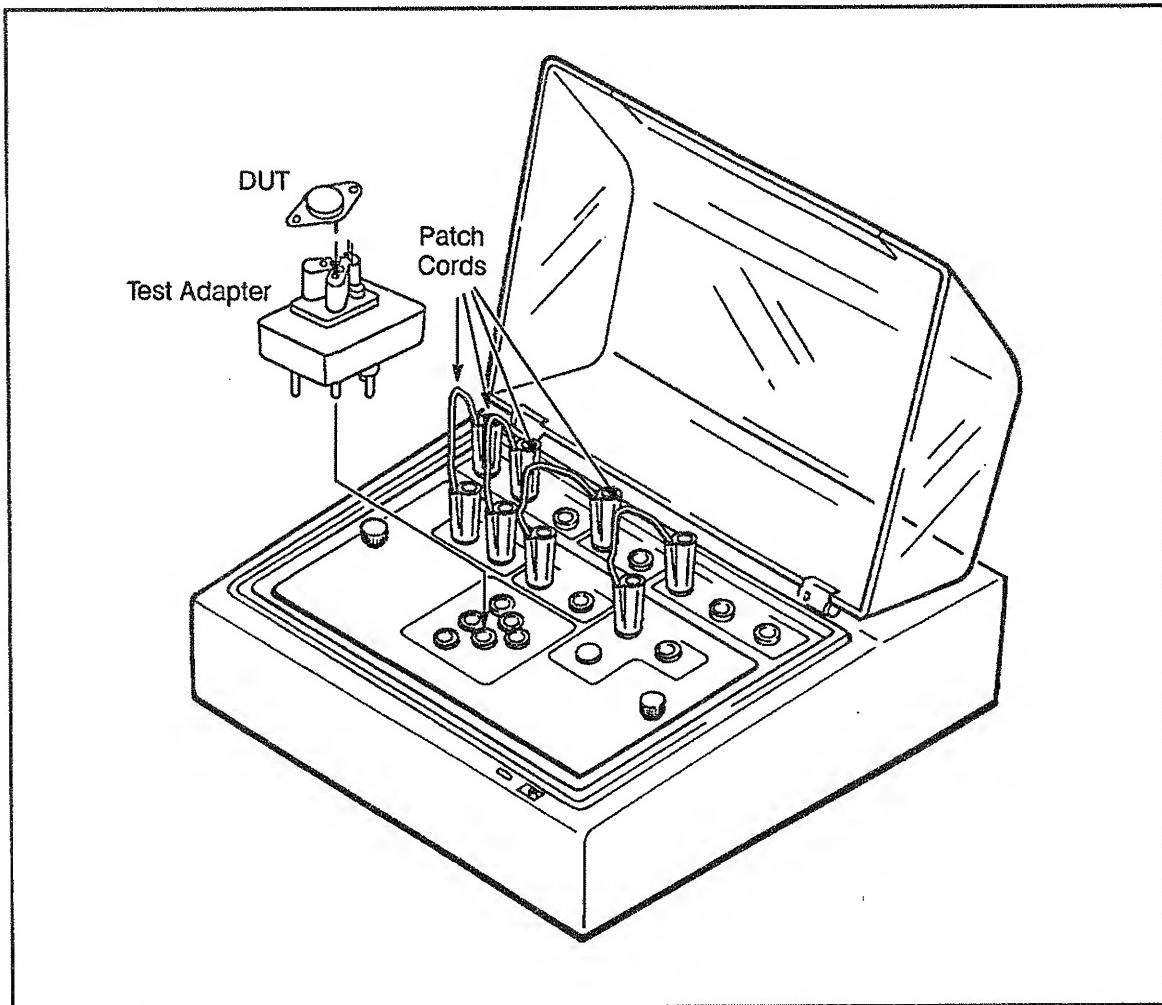
Figure 2-1. DUT connection path when using adapter panel and test adapters.

NOTE

When making high-voltage measurements, do not make connection between the COLLECTOR SUPPLY HIGH CURRENT SENSE connector and the COLLECTOR/DRAIN/ANODE SENSE connector, or between the COMMON SENSE connector and the EMITTER/SOURCE/CATHODE SENSE connector. Resulting voltage and current measurements may be incorrect.

Test Adapters

Two test adapters are provided as standard accessories for the 371A: the A1002 (In- Line Lead) and the A1003 (TO-3/TO-66). Three other test adapters are available as optional accessories: the A1001 (Blank Adapter), the A1004 (Long Lead) and the A1005 (Axial Lead).

The test adapters have voltage ratings that must not be exceeded. These voltage ratings are shown in Table 2-1.

Table 2-1
Test Adapter Voltage Ratings

Type	Case Type	Voltage Rating
A1001	Blank	
A1002	In-Line Lead Adapter	1000 V
A1003	TO-3/TO-66 Adapter	2000 V
A1004	Long Lead Adapter	1500 V
A1005	Axial Lead Adapter	2000 V

CAUTION

Do not apply voltages that exceed the voltage ratings listed in Table 2-1. Further, the adapters are plastic and can be damaged by excessive heat resulting from repetitive testing. When a test is expected to generate excessive heat, obtain a single measurement and store the pulse for display using store mode.

Figure 2-2 illustrates the pin configuration for the various test adapters.

Figure 2-3 shows the internal wiring of the adapter panel. This illustration helps to visualize signal routing from the adapter plug connections to the patch panel connections.

An optional Field Wiring Kit is also available for creating custom test fixtures. Refer to the "Optional Accessories" list in Chapter 1: General Information for the Tektronix part number and ordering information.
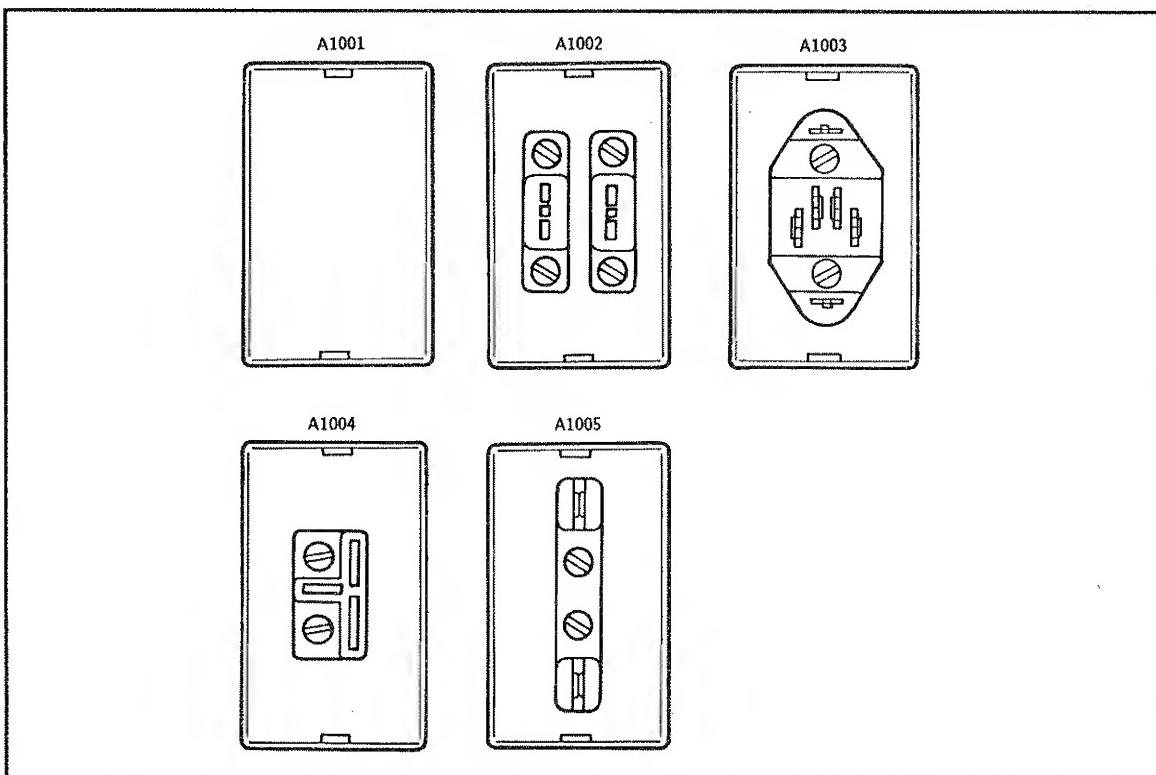
Figure 2-2. Test adapter pin configuration.
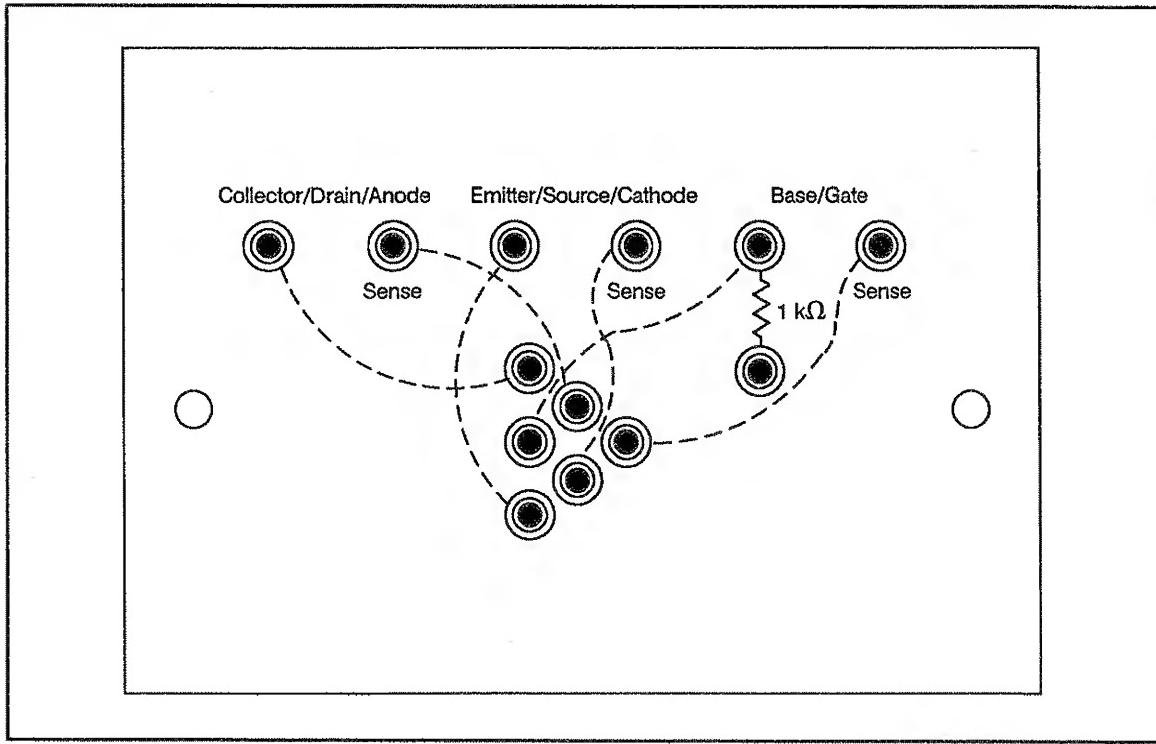
Figure 2-3. Internal wiring (signal path) of adapter panel.

Connecting A DUT Using Patch Cords

Many semiconductor devices do not have standard lead configurations or may be too large to fit into a test adapter. Patch cords with alligator clips can be used to connect a DUT directly to the test fixture unit, as described in the following paragraph.

If the physical shape or operating voltage of the DUT prevents use of a test adapter, you can easily remove the adapter panel by loosening two thumb screws and lifting the adapter panel out of the test fixture unit as shown in Figure 2-4. Now you can connect the device directly to the patch panel as shown in Figure 2-4.

TEST FIXTURE INTERLOCK

The 371A main unit/test fixture is provided with a safety interlock system that disables the collector supply voltage whenever the test fixture cover is in the raised position. Whenever the collector supply voltage is disabled you can safely connect and disconnect devices at the patch panel.

When the cover is closed, the collector supply voltage is enabled. The enabled state is indicated by a red WARNING indicator. When lit, the WARNING indicator indicates that the collector supply is enabled and that a dangerous voltage may appear at the patch panel terminals on the test fixture unit.

WARNING

Do not disable the safety interlock and then attempt to operate the 371A. You may accidently contact high voltage and serious personal injury or death may result.

The collector supply is also disabled whenever the test fixture unit cable is disconnected from its connector at the front panel of the main unit.
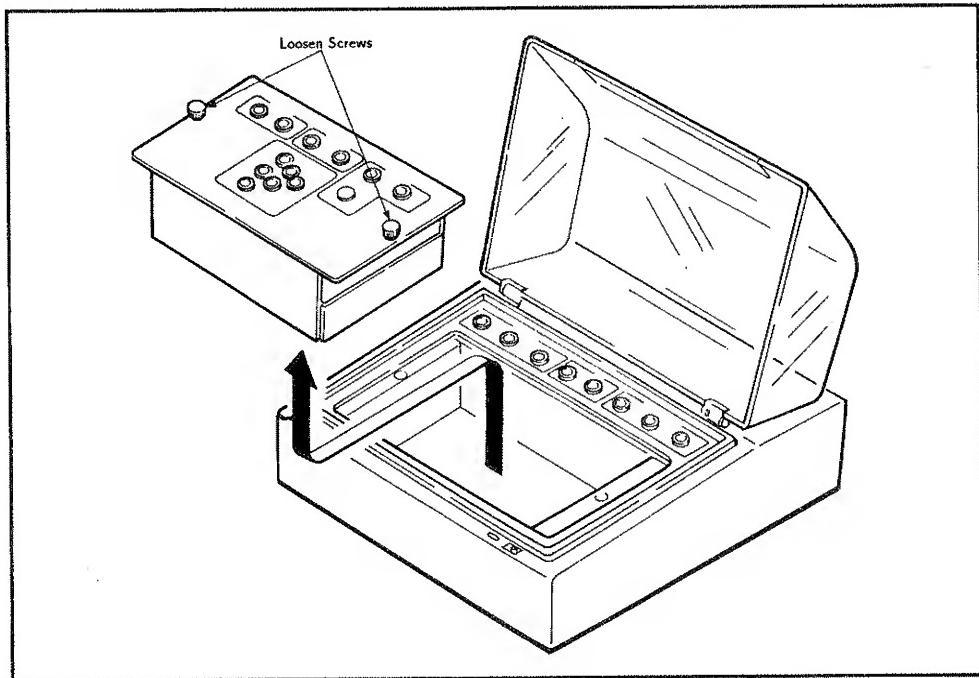
Figure 2-4. Removing the adapter panel.
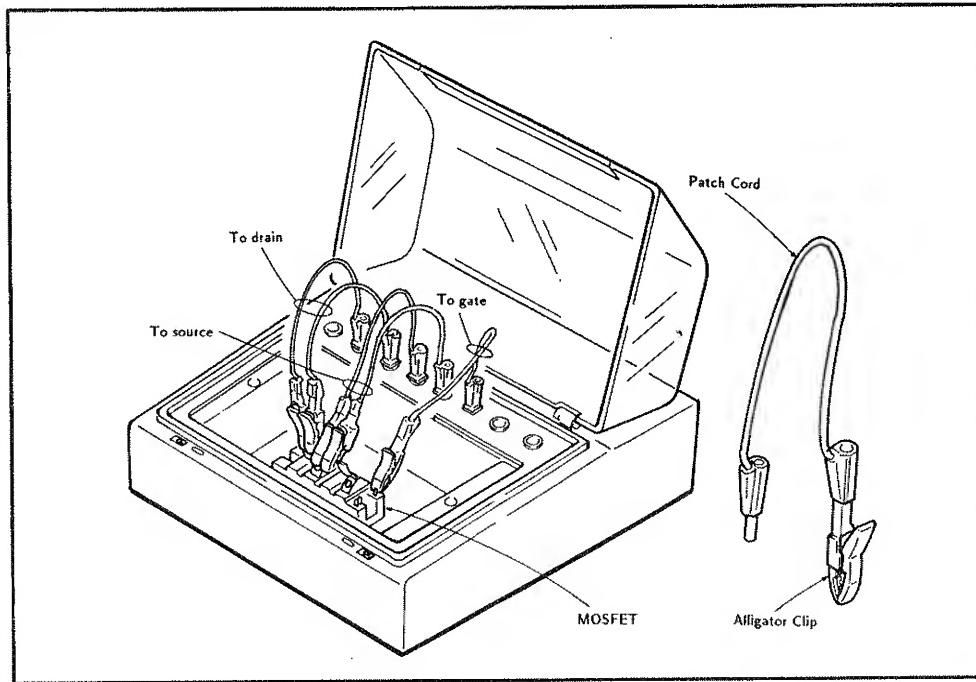
Figure 2-5.   Connecting a device directly to the test fixture unit using patch cords. In this example, connections are for measuring the common-source characteristics of an FET.

DEVICE STIMULUS

Operating stimuli (voltage and current) are provided by the collector supply and step generator circuits. The outputs from the collector supply and the step generator circuits are applied to the DUT to begin the process of producing characteristic curves, displays, and related readout information.

NOTE

When either the test fixture unit is disconnected from the main unit, or its protective cover is open (when connected to the main unit), the collector supply and step generator outputs are disabled to prevent dangerous voltages and currents at exposed connectors. The main unit also shuts down the collector supply and step generator outputs in the event overheating is detected in the output circuits.

The Collector Supply

The collector supply provides a wide range of operating voltages at various power settings for the DUT. Voltage and power selection are controlled by the collector supply controls. With these controls you can select to operate in either a high-voltage or a high-current mode (with various selections in each mode), and can select output polarity of the device to be tested, NPN+ or PNP –. In addition, you can vary the output voltage within the range determined by the maximum peak voltage selected by rotating the collector supply VARIABLE knob.

The collector supply high voltage and high current outputs are connected to the test fixture unit and appear at its COLLECTOR SUPPLY HIGH VOLTAGE and COLLECTOR SUPPLY HIGH CURRENT connectors, respectively.

Finally, the collector supply has a LOOPING COMPENSATION control that compensates for looping which sometimes occurs when the measured current is extremely low. A looping condition is evident when the displayed characteristic curve takes the form of a loop. Looping is the result of either the capacitance of the 371A and the test fixture unit, or the capacitance of the DUT.

It is not possible to completely compensate for capacitance in all semiconductor devices. The LOOPING COMPENSATION control simply provides some compensation for floating capacitance in small diodes and in voltage-driven, three-lead devices.

The Step Generator

The step generator circuit provides the current or voltage applied to the base, gate, or emitter of the DUT. You set the desired current and voltage selections using the step generator controls. The output may be either a staircase current or voltage waveform with fixed increments, or a pulse current waveform. You can select voltage or current output with the VOLTAGE or CURRENT source buttons, while the type of waveform produced is determined by both the source setting and the collector supply peak power watts setting. When the source is CURRENT and the peak power watts is set to 3 KW or 300W, the step generator outputs a pulsed waveform.

If you choose a pulsed waveform you can select from 0 to 10 steps using the number of steps up or down buttons (except when you choose 5 V or 2 A; in which case the number of steps ranges from 0 to 5). You can use the STEP/OFFSET AMPLITUDE knob to select the step amplitude. The step amplitude setting is displayed on the CRT in the PER STEP readout field.

You can reduce the step amplitude by a factor of 10 by pressing the STEP MULT .1X button. The step generator provides other features that are described in more detail in the "Operating Exercises" and "Measurement Exercises" in Chapter 3: Exercises.

The step generator voltage and step generator current signals are output to the test fixture unit and appear at its STEP GENERATOR VOLTAGE and STEP GENERATOR CURRENT connectors.

Setting Offset

You can add plus (+) or minus (–) DC offset to the step generator output signal by pressing the up or down offset buttons, respectively. The offset is the same polarity as the step generator signal. When the step signal is a staircase waveform, the offset is either a DC voltage or a DC current, depending on whether the step generator is operating in voltage or current mode. When the step signal is a current pulse, the pulse itself is offset. You can select an offset amplitude that is 1 to 10 times the step amplitude. An exception is when you have selected either the 5 V or 2 A step amplitude settings. In this case, the amount of offset is from 0 to 5 times the step amplitude. The selected offset amplitude is indicated on the CRT in the OFFSET readout area.

NOTE

The offset is independent of the STEP MULTI .1X setting and the measurement mode. The amplitude of the selected offset is always at a constant value.

Setting Polarity

The polarity of the step generator signal is switched when the polarity of the collector supply is changed. This ensures that when the collector supply POLARITY setting is NPN+, the step generator polarity is POS+, and conversely, when the collector supply POLARITY setting is PNP –, the step generator polarity is NEG –. Some FET measurements may require that you set the polarity of the step generator signal to be opposite the polarity of the collector supply signal. To do this, press the step generator INVERT button.

DATA ACQUISITION

The 371A senses the effect of the collector supply and step generator stimulus signals on the DUT and performs voltage sensing using the SENSE connectors at the patch panel. The SENSE connectors provide a high-impedance path back to the 371A for voltage measurement. The SENSE connections allow the 371A to make precise voltage measurements by making connections close to the DUT, rather than measuring the voltage at the collector or step generator output of the power supply.

The STEP GENERATOR CURRENT SENSE connector on the patch panel is for Kelvin sensing of base voltage (V_{BE}) measurements in high current mode. For Kelvin sensing purposes, this sensing connector is independent of the power supply connector. This improves the accuracy of measurements because it eliminates any voltage drop due to contact resistance.

Voltage can be measured without connecting the device to the STEP GENERATOR CURRENT SENSE connector, but for high precision measurements this sense connector should be used.

MEASUREMENT MODES

The collector supply and step generator provide voltage and current output signals for three different measurement modes: repeat, single, and sweep, as selected by the REPEAT, SINGLE, and SWEEP buttons. The particular mode selected depends on the DUT, and the specific characteristics you wish to measure.

Repeat Mode

In repeat mode, the pulse or swept outputs of the collector supply and step generator continuously repeat as selected by the collector supply and step generator controls. The repeat mode is automatically selected when the 371A is powered-up or initialized. This mode is normally used when device overheating is not a concern.

Single Mode

In single mode, the step generator outputs a single pulse or a staircase (stepped) waveform each time you press the SINGLE button. In high-current mode, the collector supply provides one pulse per number of steps selected. Thus, if device overheating is a problem, you can use single sweep mode to pulse the DUT once to acquire the desired characteristic. You can store this characteristic in memory, then display it from memory on the CRT.

Sweep Mode

In sweep mode, the pulsed collector supply or step generator output amplitude sweeps from 0 V to its preselected value. The result is a continuous curve displayed on the CRT rather than a single measured point.

In sweep mode, the collector and base of the DUT are being pulsed continuously using a low duty cycle. Because of the low duty cycle, this mode allows you to view a complete curve without overheating your device.

There is a version of sweep mode for both the collector supply and the step generator as described in the following:

Collector Supply Sweep Mode

The 371A is in collector supply sweep mode when the controls are set as follows:

Collector Supply
    VARIABLE .... any setting except 0%
    PEAK POWER WATTS .... 300 W or 3 kW

Display
    MODE .... STORE
    HORIZONTAL VOLTS/DIV .... COLLECTOR (V_{CE}) RANGE

If you try to exercise collector sweep mode with the controls in any other position, you will receive an OPERATION ERROR message.

When collector sweep mode is in effect, the collector % is displayed in the HORIZ/DIV readout area. In this mode, the collector supply output sweeps from 0% to the value selected by the collector supply VARIABLE control. When using the dot cursor, collector voltage may also be displayed.

For increased resolution, you can reduce the distance between displayed dots to one quarter their normal distance by holding down the cursor SHIFT button then pressing the SWEEP button. This action decreases the sweep speed by a factor of four.

The step generator outputs continuously in collector supply sweep mode.

Step Generator Sweep Mode

This mode sweeps the step generator output from its offset value to peak value (step amplitude + offset). The 371A is in step generator sweep mode when the controls are set as follows:

Collector Supply
    PEAK POWER WATTS .... 300 W or 3 kW

Display
    MODE .... STORE
    HORIZONTAL VOLTS/DIV .... STEP GEN (V_{BE}) RANGE

Step Generator
    OUTPUT .... any setting except 0 V (or 0 A)

If you press SWEEP and the 371A controls are set at 0 V or 0 A, the 371A will display the OPERATION ERROR message.

The sweep voltage or current is displayed in the OFFSET readout area of the display (the initial value displayed is the offset value). In sweep mode, the number of steps for the step generator defaults to 0 steps.

NOTE

The sweep end voltage or current is limited to 10 times the STEP AMPLITUDE setting, except for the 5 V or 2 A setting. If the STEP AMPLITUDE setting is 5 V or 2 A, the sweep end voltage or current is limited to five times the STEP AMPLITUDE setting.

You can reduce the distance between displayed dots to one-half their normal distance by holding down the cursor SHIFT button then pressing the SWEEP button. This action decreases the sweep speed by a factor of two.

The collector supply outputs continuously when in step generator mode.

Defeating Sweep Mode

If you change any front-panel control (except for the controls listed in Table 2-2), the 371A reverts from sweep mode to repeat mode.

Saving Sweep Mode Settings

You can save sweep mode settings in mass storage by selecting a memory location and pressing the SAVE button during the sweep. Refer to "Mass Storage and Memory" later in this chapter for more information on saving settings.

Table 2-2
Controls That Do Not Defeat Sweep Mode

Control Group	Specific Control
Setup	SAVE
Memory	Index Selection Buttons
Display	REF, ENTER
Cursor	Mode Selection Buttons, Position Buttons
GPIB	RESET TO LOCAL, USER REQUEST PLOT

Saving Sweep Mode Data

Like other displays, you can save sweep mode displays in mass storage by pressing the display ENTER button during the sweep. All data captured up to the point you pressed ENTER are stored at the memory location you specified, and the sweep continues. When the setting is recalled, sweep mode is automatically selected by the 371A. Refer to "Mass Storage and Memory" later in this chapter for more information on saving settings.

DEVICE CHARACTERISTICS DISPLAY

The CRT displays the effect the collector supply and step generator signals have on the DUT.

Refer to Figure 2-6. The display screen has two basic display areas: the curve setup area and the reference curve display area.

Curve Setup Area

This area consists of a display column that provides individual readouts for VERT/DIV, HORIZ/DIV, PER STEP, OFFSET, or gm/DIV, % of COLLECTOR PEAK VOLTS, and cursor measurement readouts. When the reference curve is displayed, readout data of the store or view curve are displayed. Additional operating details are provided in "Operating Exercises" and "Measurement Exercises" in Chapter 3: Exercises and in Chapter 4: Controls, Indicators, and Connectors.
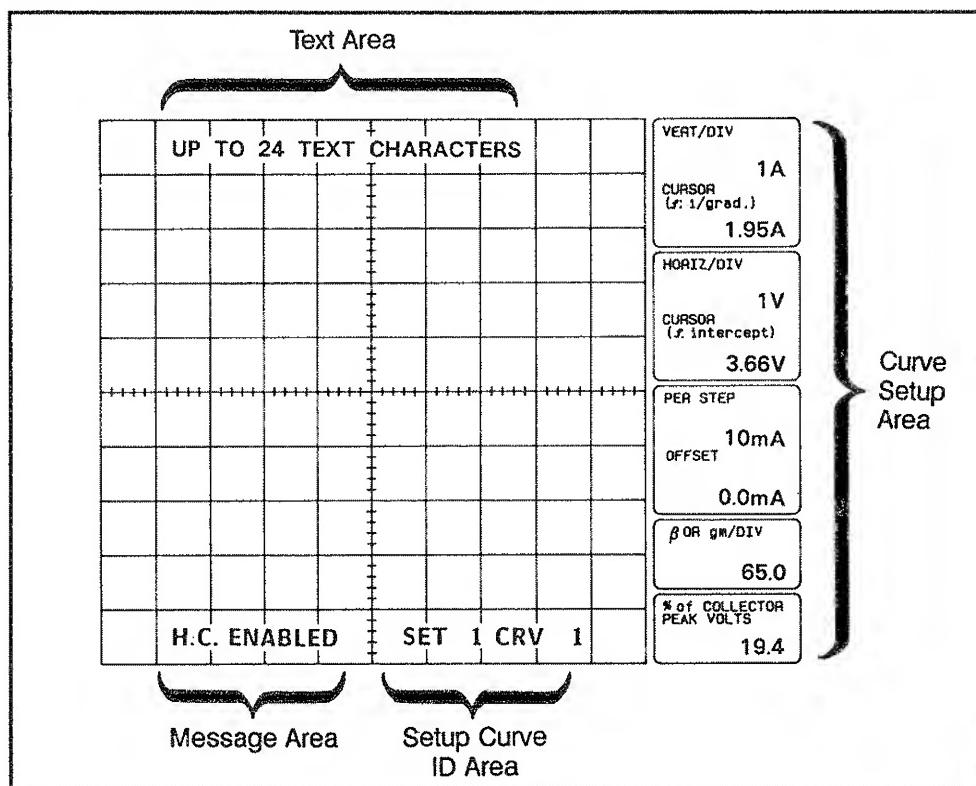
Figure 2-6. Display screen and its display areas.

Curve Display Area

This area consists of a 10 X 10 grid in which the measurement curve and text may be displayed. Text areas are provided within the top-most and bottom-most vertical grids to display text for the following purposes:

* text area
* setup/curve area
* the vertical axis
* the horizontal axis

Text Area

You can enter up to 24 characters in this area. Text is useful for identifying specifications or device type. Text may be stored and recalled with setups and curves.

Text entry is made using the display controls and the cursor SHIFT button. A text editing exercise is provided in "Operating Exercises" Chapter 3: Exercises.

Message Area

Messages up to 14 characters (such as OPERATION ERR, SAVE COMPLETE, CHECKSUM ERROR, etc.) are displayed in the bottom left corner of the 10 X 10 grid. These messages are displayed for about five seconds and then automatically erased. Refer to Appendix C: Messages for a complete list of messages.

Setup/Curve ID Area

This area in the bottom–right corner of the 10 X 10 grid displays text that identifies the memory location of the currently displayed reference curve and display setup (the setup ID). To display the memory location of the currently displayed reference curve, press the VIEW button. To display the memory location of the current display setup, press the RECALL button.

The Vertical Axis

The vertical axis shows the current flowing through the COLLECTOR/DRAIN/ANODE connector on the adapter panel. Vertical axis sensitivity is set by the VERTICAL CURRENT/DIV (vertical current per division) knob. The range of available settings depends on the setting of the collector supply peak power watt buttons as listed in Table 2-3.

TABLE 2-3
Vertical Axis Display Settings

Peak Power Watts Setting	VERTICAL CURRENT/DIV Setting Range
3 KW	1 A/DIV to 50 A/DIV
300 W	500 mA/DIV to 5 A/DIV
30 W	100 µA/DIV to 5 mA/DIV
3 W	10 µA/DIV to 500 µA/DIV
300 mW	10 µA/DIV to 500 µA/DIV
30 mW	1 µA/DIV to 50 µA/DIV

The selected vertical sensitivity is displayed in the VERT/DIV (vertical per division) display area on the CRT.

The Horizontal Axis

The horizontal axis shows the voltage between either the COLLECTOR/DRAIN/ANODE and COMMON connectors or between the BASE/GATE and COMMON connectors of the patch and adapter panels. Voltage sensitivity is set by the HORIZ VOLTS/DIV (horizontal volts per division) control as follows:

When turned an appropriate number of positions clockwise, the HORIZ VOLTS/DIV control selects the collector measurement (V_{CE}) and sets the horizontal sensitivity in one of the ranges listed in Table 2-4

TABLE 2-4
Horizontal Sensitivity Ranges

Peak Power Watts Setting	HORIZ VOLTS/DIV Setting Range
3 KW/300 W	100 mV/DIV to 5 V/DIV
30 W/3W	50 mV/DIV to 500 V/DIV
300 mW/30 mW	5 mV/DIV to 50 V/DIV

When turned an appropriate number of positions counterclockwise, the HORIZONTAL VOLTS/DIV knob selects the STEP GENERATOR (V_{BE}) measurement and sets the horizontal sensitivity in the range of 100 mV/DIV to 5 V/DIV.

The selected horizontal sensitivity is displayed in the HORIZ/DIV readout area of the curve setup display.

DISPLAY MODES

The 371A displays characteristic curves in one of four modes; non-store, store, view, and reference. The particular mode you choose depends on the measurement application.

Non-Store Display Mode

To enter non-store display mode, press the display NON-STORE button. The characteristic curve is displayed in real-time on the display screen. This mode can be used to observe rapid variations in a waveform.

NOTE

You cannot save a displayed curve to mass storage when in the 371A is in non-store display mode.

Store Display Mode

This is the default (power-up) display mode. It can also be entered from one of the other display modes by pressing the display STORE button.

When the 371A is in store display mode, the characteristic curve is first digitized, stored in main memory, then reconverted to analog signals for display on the display screen. The display settings, readout values and any displayed text are also displayed. You can save the stored characteristic curve (with readout values and any displayed text) in mass storage by pressing the display ENTER button.

View Display Mode

View display mode allows you to display a saved curve from mass storage. A saved curve is displayed by selecting its memory location number, then pressing the display VIEW button.

NOTE

The intensity of the characteristic curve when in non-store, store, or view modes is controlled with the NON-STORE/STORE/VIEW intensity knob.

Reference Display Mode

The 371A has a portion of memory allocated for a reference waveform. When the display REF (reference) button is pressed, the currently displayed store or view mode waveform is saved in reference waveform memory. This waveform becomes a reference which remains displayed on the display screen even when the display mode is switched between store and view modes. Thus, the reference display mode can be used to

* compare a "live" curve with a previously saved curve

* compare two previously saved curves

This display mode is useful for matching semiconductors for similar characteristic curves, as well as for other curve comparison applications.

The intensity of the reference curve is controlled with the REF INTENSITY knob; the intensity of the store and view curves is controlled with the NON-STORE/STORE/VIEW INTENSITY knob. Since these are two different controls, you are able to set a different intensity for the reference and comparison curves for easy identification.

The reference curve remains displayed until the REF button is pressed again, or non-store display mode is selected.

The "Measurement Exercises" in Chapter 3: Exercises, demonstrate how to use the reference display mode.

DISPLAY CURSORS

The 371A has three types of display cursors which help make precise measurements: a window cursor, a dot cursor, and an f line cursor. Table 2-5 lists the relationships of these cursors.

Table 2-5
Relationships Between Cursors and Readout Display

Cursor mode	Display mode	ß or gm/DIV readout display	Cursor Readout Display (f:1/gradient)	Cursor Readout Display (f:intercept)
Off	all	ß or gm/DIV		
Window	all	ß ΔI_C ΔI_B or gm ΔI_D ΔV_{GS}	Current at bright dot position	Voltage at bright dot position
Dot	store, view	High Current Mode: I_C/I_B or I_D/V_{GS} High Voltage Mode: ß or gm/DIV	Current at cursor position	Voltage at cursor position
f line	store, view	ß or gm/DIV	On-state resistance (HORIZONTAL is in COLLECTOR range) or gm (HORIZONTAL in STEP GEN range)	Voltage at which the cursor intercepts the horizontal axis.

Window Cursor

The window cursor is displayed as a rectangle with a bright dot in either the bottom left or top right corner, as selected by the cursor mode selection buttons. The cursor position buttons change the size of the window. The window cursor can be used to check visually that the characteristics of a DUT are within a specific range.

A stored window with a front-panel setup can be recalled from memory and used to provide a visual pass/fail reference for a measured device. It can also be used to measure the ß ΔI_C ΔE_B on the curve of the collector current versus collector/emitter voltage of a transistor. It can also be used to measure the gm ΔI_D ΔV_{GS} on the curve of the drain current versus drain/source voltage of an FET.

The current and voltage values at the position of the bright dot are displayed in the CURSOR readout area on the display screen. When the bottom left dot and top right dot are positioned on two adjacent curves, respectively, the h_{fe} or gm value is displayed in the ß or GM/DIV readout area. Demonstrations on how to use the window cursors are provided in "Measurement Exercises" Chapter 3: Exercises.

The window cursor can be used in non-store as well as store mode, and it can be displayed at any point on the screen.

Dot Cursor

The dot cursor is an intensified spot that can be positioned at any point on a characteristic curve. This cursor displays the current and voltage values at its position on the characteristic curve. These values are displayed in the appropriate readout area. In high-current operation, DC current gain (I_C/I_B) or DC forward transfer admittance (I_D/V_{GS}) at the cursor position is displayed in the ß or gm/DIV readout. Demonstrations on how to use the dot cursor are provided in "Measurement Exercises" Chapter 3: Exercises.

f Line Cursor

The f line cursor is displayed as a straight line that passes through the dot cursor position. Its slope can be varied by the four cursor position buttons (up, down, left, and right). The f line cursor is useful for measuring the on-state resistance of a device and for measuring the forward transfer admittance of FETs.

When COLLECTOR (V_{CE}) is displayed on the horizontal axis, the CURSOR (f:1/grad) readout area on the display indicates the resistance ($\Delta V_{CE}/\Delta I_C$), while the CURSOR (f:intercept) readout area indicates the voltage value at which the f line cursor intercepts the horizontal axis.

When STEP GEN (V_{BE}) is displayed on the horizontal axis, the CURSOR (f:1/grad) readout indicates the forward transfer admittance ($\Delta I_D/\Delta V_{GS}$) while the CURSOR (f:intercept) readout indicates the voltage value at which the f line cursor intercepts the horizontal axis.

Demonstrations on how to use the f line cursor are provided in "Measurement Examples" Chapter 3: Exercises.

TEXT EDITING

The 371A has a text editing mode for adding or modifying displayed text. Text is useful for labeling characteristic curve displays for ease of identification and to note conditions by which the measurement was obtained. Text is stored, in mass storage, along with the characteristic curve or setup information.

Text consists of a full range of uppercase alpha characters, numbers, and symbols. Up to 24 characters can be displayed in the upper part of the display screen.

Using Text Edit Mode

The following is a description of the functions associated with text edit mode. These functions are summarized in Table 2-6.

Initiate Text Edit Mode

To initiate text edit mode, hold down the cursor SHIFT button, then press the ENTER button. The TEXT EDIT MODE message is displayed at the bottom of the display area (for about five seconds), and the text edit cursor is displayed at the first character position of the text edit display area. The 371A is ready for text entry.

Position Text Cursor

To position the text cursor to one of the 24 character positions, press the right or left cursor position buttons.

Select A Character

To select an alphanumeric or symbol character, press the up cursor button to move forward through the character string, or press the down cursor button to move backward through the character string. Once displayed, characters remain in position until they are either over-written or erased.

Erase a Character

To erase a displayed character, position the text cursor over the character to be erased, then press the cursor SHIFT button. The cursor then moves to the next character position. To erase all text under and to the left of the cursor, simultaneously press the left and right cursor buttons. Text is erased and the cursor with all text to the right of the cursor moves to the left, with the cursor moving to the left-most position of the text string.

Exit Text Edit Mode

To exit text edit mode without saving text changes, press either the STORE or NON-STORE buttons. All displayed text is erased and the message TEXT CANCELLED is displayed.

To exit text edit mode and save text changes, press the ENTER button (also saves a displayed characteristic curve). Text edit mode ends and the 371A returns to normal operation.

Text can also be saved as follows:

• to save text with front-panel setup information, press the SAVE button

• if text was entered when in view mode, text is automatically saved upon exiting view mode

Display a Directory of Stored Text

To display a directory of stored text, hold down the cursor SHIFT button, then press the RECALL button. Refer to "The File Directory" under "Memory and Mass Storage" immediately following for details.

Table 2-6
Summary of Text Editing Functions

Function	Action
Initiate Text Edit Mode	Hold down cursor SHIFT button, then press ENTER button.
Position text cursor	Press the right or left cursor buttons depending on the direction you want to move the cursor.
Select a character or symbol	Press the up or down cursor buttons to move forward or backward through the string of displayable characters and symbols. Characters and symbols are displayed at the text cursor position.
Erase a character or symbol	Use the right or left cursor buttons to position the text cursor on the desired character, then press the cursor SHIFT button.
Erase all text under and and to left of cursor	Simultaneously press the right and left cursor buttons.
Exit without saving	Press either the STORE or NON-STORE buttons.
Exit and save	Press the ENTER button.
Save text with front-panel setup information	Press the SAVE button.
Display directory of stored text	Hold down the cursor SHIFT button, then press the RECALL button.

MEMORY AND MASS STORAGE

The 371A mass storage system consists of non-volatile memory and a 3.5 inch floppy disk drive. This system is used to store both characteristic curve data (with display settings, readout values, and displayed text) and front-panel settings.

NOTE

High-density disks (1.2 MByte) cannot be used in the floppy disk drive. Use double density (740 kByte) disks only.

Chapter 3
EXERCISES

Information in this chapter provides a sequence of exercises designed to acquaint the first-time user with the basic procedures required to perform device measurements and setups. These exercises are divided into two groups: Operating Exercises which acquaint you with 371A controls and related functions and, and Measurement Exercises which acquaint you with the fundamentals of performing semiconductor device measurements.

NOTE

These procedures do not verify that the 371A meets the performance specifications listed in Appendix A. To verify that the 371A meets performance specifications, a qualified technician must perform the procedures provided in Chapter 4: Performance Check and Adjustment of the 371A Service manual.

OPERATING EXERCISES

These exercises acquaint you with how the 371A displays, captures, and analyses semiconductor test data. Here you will find a description of the 371A power-up sequence. Following a successful power-up (during which diagnostics are automatically run), you have reasonable assurance that the 371A will perform measurements as specified and described in this manual.

These procedures are designed to acquaint the first-time user with control operations used to obtain and analyze semiconductor performance information with the 371A. After you have performed these procedures, you will be ready to work through the measurement exercises.

Operating exercises are presented in the following order:

- powering-up the 371A and storing power-up default settings

- exercising display controls

- checking the calibration reference voltage and display invert feature

- exercising setup, save, and recall features

- exercising vertical and horizontal sensitivity controls

- exercising text editing features

- formatting floppy disks

- verifying floppy disk operation

- displaying the memory directory

- erasing non-volatile memory

- verifying plotter output

NOTE

These procedures assume that the test fixture unit is connected to the 371A and that the 371A is connected to a power source as described in Appendix D: Installing and Repacking.

Powering-Up the 371A and Storing Power-Up Default Settings

This procedure describes the power-up sequence and how to store the power-up default settings for use in various procedures throughout this chapter.

1. Set the collector supply HIGH VOLTAGE and HIGH CURRENT breakers to the DISABLED position.

2. Set the 371A POWER switch to ON.

   The 371A automatically begins performing a self-test routine. During this routine the memory location number is displayed in the following sequence:

   a. The memory LED display is set to 00 and the message SELFTEST START is displayed in the message area (bottom left corner) of the CRT.

   b. The left digit of the memory location LED counts down from 9 to 1, then the right digit counts down from 9 to 0.

   The self test lasts less than ten seconds. If no error is detected, the message SELFTEST PASS is displayed and the 371A is set to its initial state. The initial state (default) settings are listed in Table 3-1.

3. Allow the instrument to warm up for a few minutes before proceeding.

4. Press the SAVE button to store the default settings in memory location 1. These default settings are used as a starting point for each major step throughout the following procedures.

Table 3-1
Initial State Settings

Control	Setting
Measurement Mode	REPEAT
MEMORY Index	1
Display	
Mode	STORE
VERTICAL CURRENT/DIV	1 A
HORIZONTAL VOLTS/DIV	COLLECTOR V_{CE}, 1V
INVERT	OFF
Cursor Mode	OFF
Collector Supply	
PEAK POWER WATTS	HIGH CURRENT 300 W
POLARITY	NPN
VARIABLE	0.0%
Step Generator	
SOURCE	CURRENT
AMPLITUDE	1 mA
INVERT	OFF
NUMBER OF STEPS	2
OFFSET	0.00 MA
STEP MULTI .1X	OFF
GPIB	
LOCAL/REMOTE	LOCAL
SRQ	SRQ Power ON

Exercising the Display Controls

The following steps demonstrate the effects of the CRT display controls and how to adjust them for optimum display viewing.

1. Turn the NON STORE/STORE/VIEW INTENSITY control clockwise until a spot appears at the bottom left corner of the CRT graticule. To avoid burning the CRT phosphor, adjust the NON STORE/STORE/VIEW INTENSITY control until the spot is just visible.

2. Turn the FOCUS control throughout its range. Adjust the FOCUS control for a well-defined spot.

3. Turn the READOUT/CURSOR INTENSITY control throughout its range. Note that the readout becomes brighter as the control is turned clockwise. Set the control for the desired readout brightness.

   The initial displayed control settings should be displayed as listed in Table 3-2.

Table 3-2
Display Area Readout at Power-Up

Readout Area	Reading
VERT/DIV	1 A
CURSOR (f: I/grad)	none
HORIZ/DIV	1 V
Cursor (f: I/intercept)	none
PER STEP	1 mA
OFFSET	0.00 mA
β or gm/DIV	1 K
% of COLLECTOR PEAK VOLTS	0.0

4. Turn the GRAT ILLUM control throughout its range. Note that the graticule lines and the readout titles brighten as the control is turned clockwise. Set the control for desired illumination.

Checking the Calibration Reference Voltage and Display Invert Feature

These steps demonstrate the use of the CAL ZERO (calibration zero) and CAL FULL (calibration full) controls to check display calibration. The effect of the display INVERT control is also demonstrated.

1. Select the dot cursor.

2. Hold down the cursor SHIFT button, then press the VIEW button. This sets the 371A to zero calibrate (CAL ZERO) operation.

    Note that the displayed dot is located on or near the bottom left corner of the display graticule and the word CAL is displayed in the top right corner.

3. Turn the vertical screwdriver POSITION control to align the displayed dot with the bottom graticule line.

4. Turn the horizontal screwdriver POSITION control to align the displayed dot with the left-most graticule line.

    The displayed dot should now be positioned directly on the bottom left corner of the CRT graticule.

5. Check that the VERT CURSOR readout does not exceed ±0.02 A. Check that the HORIZ CURSOR readout does not exceed ±0.02 A.

    The zero calibrate feature provides a reference voltage for checking the calibration voltage at the bottom left corner of display graticule.

    If vertical or horizontal readouts exceed the values listed above, refer a qualified technician to "Examining Calibration Voltage" in Chapter 4: Performance Check and Adjustment of the *371A Service* manual.

NOTE

Failure of the instrument to meet the functional characteristic stated above will not prevent you from being able to continue with these operating exercises.

6. Hold down the cursor SHIFT button, then press the STORE button. This sets the 371A to full calibrate (CAL FULL) operation.

    Note that the displayed dot is located at the top right corner of the display graticule.

7. Check that the VERT CURSOR readout is between 9.98 A and 10.02 A. Check that the HORIZ CURSOR readout is between 9.98 A and 10.02 A.

    The full calibrate feature provides a reference voltage for checking the calibration voltage at the top-right corner of display graticule.

    If the vertical or horizontal readouts exceed the values listed above, refer a qualified technician to "Examining Calibration Voltage" in Chapter 4: Performance Check and Adjustment of the *371A Service* manual.

NOTE

Failure of the instrument to meet the functional characteristic stated above will not prevent you from being able to continue with these operating exercises.

8. Hold down the cursor SHIFT button, then press the REF (reference) button. This sets the 371A back to normal operation (CAL OFF).

9. Press the display INVERT button.

10. Observe that the dot is displayed in the top right corner of the display graticule.

11. Press the display INVERT button once again to resume normal operation.

Exercising Setup Save and Recall Features

These steps demonstrate the ability of the 371A to save and recall front-panel setups.

1. Press the memory up button to select memory location 4.

2. Set front panel controls as follows:

Display
    VERTICAL CURRENT/DIV .... 5 A
    HORIZONTAL VOLTS/DIV .... 200 mV

Step Generator
    STEP/OFFSET AMPLITUDE .... 10 mA/Step

Collector Supply
    POLARITY .... PNP – (note that step generator
                                                    INVERT indicates NEG –)

Note the corresponding changes in the display readouts on the CRT.

3. Press the setup SAVE button.

4. Change any or all of the controls that were set in Step 2 to different settings.

5. Press the setup RECALL button and note that front-panel settings are reset to the settings saved in Steps 2 and 3.

6. Simultaneously press the up and down memory buttons. Note the the memory location number is set to 1.

7. Press the RECALL button to reset the initial power-up control settings.

Exercising Vertical and Horizontal Sensitivity Controls

These steps demonstrate the operation of the vertical and horizontal sensitivity controls. This exercise requires that a 1 Ω resistor with at least a 4 W rating be installed in the test fixture unit.

Test Fixture Unit Setup

The 1 Ω resistor can be installed in the test fixture unit using an optional A1005 test adapter, or it can be connected using patch cords as described in the following steps.

1. Obtain a 1 Ω resistor with at least a 4 W rating.

2. Open the protective cover on the test fixture unit.

   If using the A1005 test adapter, perform Step 3. If using patch cords, perform Step 4.

NOTE

For details about the patch panel and the adapter panel, refer to the discussion under "Test Fixture Unit" in Chapter 2: General Operation.

3. If using an A1005, proceed as follows:

   A. Insert the A1005 test adapter into the test adapter connector on the adapter panel.

   B. Connect the patch cords between connectors on the patch panel and the adapter panel as shown in Figure 3-1.

   C. Close the protective cover.

4. If you are using patch cords, perform the following:

   A. Remove the adapter panel as described under "Test Fixture Unit" in Chapter 2: General Operation.

   B. Using patch cords with alligator clips, connect the 1 Ω resistor to the test fixture connectors as follows:

   - Connect the COLLECTOR SUPPLY HIGH CURRENT and COLLECTOR SUPPLY HIGH CURRENT SENSE to one end of the resistor.
   - Connect the COMMON and COMMON SENSE to the other end of the resistor.

   C. Close the protective cover on the test fixture unit.

Proceed with the following control exercises.
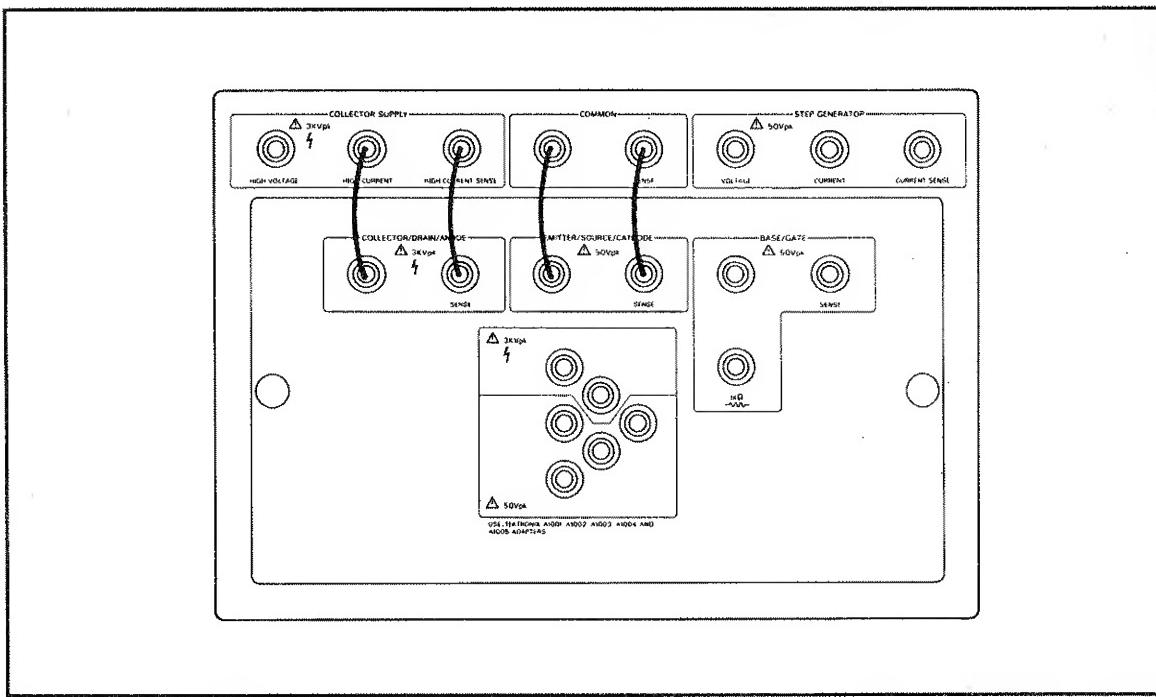
Figure 3-1. Patch cord connections for vertical and horizontal sensitivity exercise.

Exercising the Controls

The following steps use the test fixture unit setup as described in the preceding four steps.

1. Set the collector supply HIGH CURRENT breaker to the ENABLED position.

2. Slowly rotate the collector supply VARIABLE knob clockwise.

   Observe that the dot on the screen moves along a diagonal line from the bottom left corner to the top right corner of the display graticule.

3. Rotate the collector supply VARIABLE knob counterclockwise to move the dot to the center of the display.

4. Rotate the VERTICAL CURRENT/DIV knob clockwise, increasing vertical sensitivity.

   Observe that the dot moves upward.

5. Rotate the VERTICAL CURRENT/DIV knob counterclockwise until the sensitivity is set to 5 A/DIV.

   Observe that the dot moves downward.

6. Return the VERTICAL CURRENT/DIV knob to the 1 A/DIV setting.

7. Rotate the HORIZONTAL VOLTS/DIV knob clockwise, increasing horizontal sensitivity.

   Observe that the dot moves to the right.

8. Turn the HORIZONTAL VOLTS/DIV knob counterclockwise until the sensitivity is set to 5 V/DIV.

    Observe that the dot moves to the left.

9. Return the HORIZONTAL VOLTS/DIV knob to the 1 V/DIV setting.

10. Press the display INVERT button.

    Observe that the red INVERT light turns on.

11. Rotate the collector supply VARIABLE knob clockwise.

    Observe that the dot moves toward the bottom left when the knob is turned clockwise and toward the top right when the knob is turned counterclockwise.

    The origin of the graticule is now in the top right corner and the direction of dot movement is the inverse of normal operation.

12. Continue with the following exercise.

Checking Vertical Sensitivity in High Current Mode

These steps demonstrate vertical sensitivity characteristics in high current mode.

1. Observe that the memory location number is 1, then press the setup RECALL button to initialize the 371A.

2. Select the dot cursor.

3. Rotate the collector supply VARIABLE knob to move the dot to the approximate center of the display.

    Note the current reading in the VERT/DIV readout area of the CRT.

4. Press the collector supply peak power watts 3 KW button.

5. Turn the VERTICAL CURRENT/DIV knob clockwise until the sensitivity is set to 1 A/DIV.

6. Observe that the current for the 3 KW setting increases from its previous position (noted in Step 3) for 300 W (default) setting.

7. Set the collector supply HIGH CURRENT breaker to the DISABLED position, then open the protective cover.

8. Remove the resistor from the test adapter or from the patch cords, and close the protective cover.

Exercising Text Editing Features

This procedure demonstrates how text is entered and saved by the 371A. As explained in Chapter 2: General Operation, user-entered text is useful for identifying characteristic curve displays and setups that are stored and recalled for later use.

1. Hold down the cursor SHIFT button and then press the ENTER button. You are now in text entry mode.

    The message TEXT EDIT MODE is displayed for about five seconds, and the blinking text cursor appears in the left-most character position of the 24-character text line at the top of the display.

2. Alternately press and release the up cursor position button and observe that characters are displayed at the cursor position in the following sequence.

    space A B . . . Z SPACE m μ n p . 0 1 . . . 9 - / * ( ) =

    ### NOTE

    The 371A substitutes the Greek letter "μ" for the lower-case "u."

    Once displayed, characters remain in place until written over or erased, as described below.

3. Press either the right or left cursor button to move the cursor to a different character position. Observe that the text cursor moves without altering the displayed text. (The cursor wraps around to the opposite end of the text line when moving past either end.)

4. Use the four cursor position buttons to enter any desired text sting of up to 24 characters.

5. Move the cursor to the middle of the text string.

6. Press the cursor SHIFT button and observe that the character at which the cursor is displayed is erased and the cursor moves to the next position on the left.

7. Simultaneously press the left and right cursor position buttons, and observe that text is deleted and that the text cursor moves to the left side of the text area.

8. Enter another text string.

9. Press the ENTER button to exit the text edit mode.

    Observe that the text cursor disappears from the display and that the text remains as displayed.

10. Change the memory location to 3 and press the display ENTER button.

    The entered text is now stored in memory.

11. Change the memory location to 1 and press the setup RECALL button. This initializes the 371A to the initial power-up settings once again.

    Observe that the entered text is cleared from the display.

12. Change the memory location number back to 3, then press the display VIEW button.

    Observe that the previously stored text is displayed once again.

13. Change the memory location to 1 and press the setup RECALL button to initialize the 371A.

Formatting Floppy Disks

CAUTION

Saving to a memory location overwrites with new data. Therefore, before saving a file to a memory location, check the memory location using the file directory feature. Make sure that it does not contain a file that you may need.

1. Obtain a blank 3.5 inch floppy disk (2DD type). If the floppy disk is write-protected, move the write protect tab to the WRITE-ENABLE position (shown in Figure 3-2).

NOTE

If you attempt to format a disk with the write protect tab set at the WRITE PROTECT position, the message WRITE PROTECT *appears, and the formatting function is canceled.*

2. Insert the disk with the label side up (see Figure 3-3) pushing it in firmly until it clicks into place.

3. Hold down the cursor SHIFT button and press the SAVE button. Now immediately press the SAVE button again before the message PRESS SAVE disappears from the display screen (you have about five seconds).

NOTE

If the SAVE button is not pressed during the time the message PRESS SAVE *is displayed, the message* FORMAT ABORTED *is displayed and the 371A returns to the preselected operating mode.*
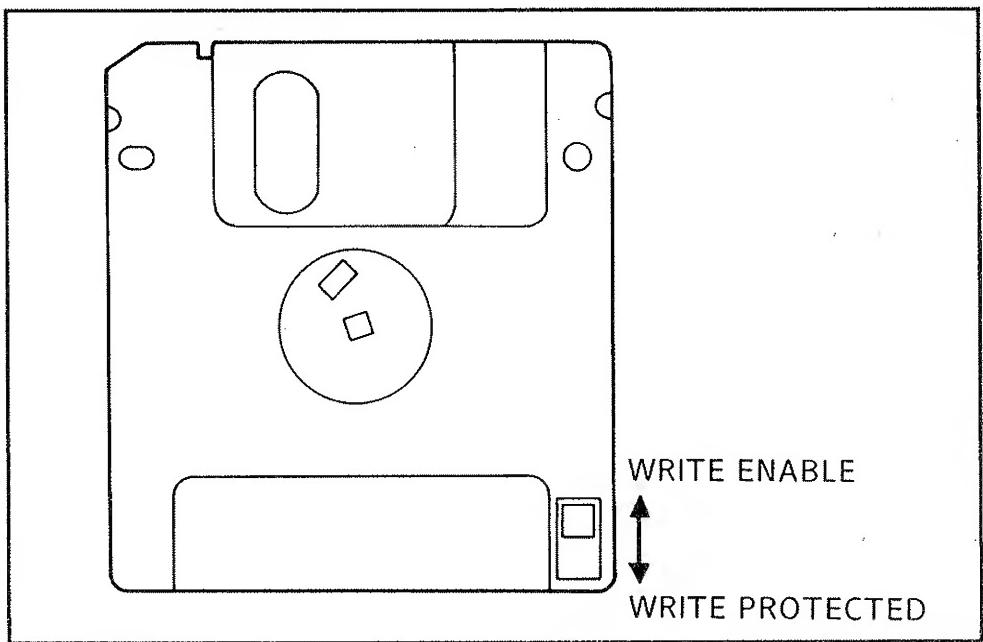
Figure 3-2. Floppy-disk write-protect tab.

WRITE ENABLE

WRITE PROTECTED

EJECT BUTTON
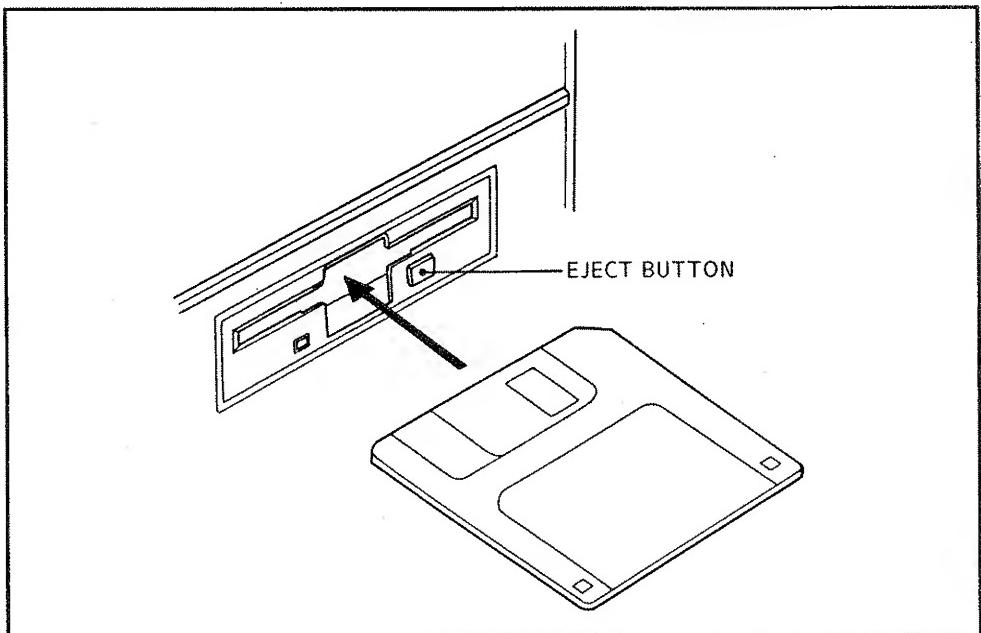
Figure 3-3. Inserting a floppy disk into the disk drive.

Verifying Floppy Disk Operation

The following steps verify that the 371A will write to and read from a formatted floppy disk.

1. Insert a formatted floppy disk into the disk drive.

2. Set the memory location to 3 then press the display VIEW button.

   Observe that the text entered in the preceding text editing exercise is displayed.

3. Change the memory location to 17.

4. Press the display ENTER button. The disk drive indicator flashes for a short period, indicating that the text data is being written to the floppy disk.

5. Simultaneously press the memory up and down buttons to set the memory location number to 1, then press the setup RECALL button to initialize the 371A.

   Observe that the displayed text disappears.

6. Change the memory location number back to 17, then press the display VIEW button.

   Observe that the text data displayed in Step 2 is displayed once again.

7. Select memory location 1 again and press the setup RECALL button to reinitialize the 371A.

Displaying the Memory Directory

The following procedure demonstrates how to display a directory of memory and floppy disk contents. Refer to "Memory and Mass Storage" in Chapter 2: General Operation for additional information about the 371A memory and the directory display feature.

1. Hold down the cursor SHIFT button and then press the setup RECALL button.

   Observe that a partial directory (the first page) of memory contents is displayed beginning at memory location 1. (Numbers displayed by the memory location LEDs represent the number of the directory page currently being displayed.)

2. Press the memory up button and observe that the number in the memory location LED changes to represent the number for the new directory page being displayed.

3. Press the memory up button several times and note that the words – CURVE – and – SETUP – are alternately displayed as you page up (or down) through the directory.

4. To exit the directory display, use any front panel control other than memory up or down, SAVE, RECALL, or cursor SHIFT.

Erasing Non-Volatile Memory

The following steps describe how to erase all data stored in non-volatile memory.

```
CAUTION
```

*The following procedure erases ALL DATA stored in non-volatile memory
(memory locations 1-16). Do not perform this operation if you have any
important data stored in non-volatile memory.*

1. Hold down the cursor SHIFT button and press the display INVERT button. This changes
    the function of the INVERT button to erase. (Note that this function name is not printed
    below the button.)

    The message PRESS INVERT is displayed for about five seconds.

2   Press the INVERT button once again before the message PRESS INVERT disappears
    from the display screen.

    If you fail to press the INVERT button once again within the allotted time, the message
    ERASE CANCELED is displayed and the 371A returns to normal operating mode.

3. When non-volatile memory is erased, the message ERASE COMPLETE is displayed.

Verifying Plotter Output

These steps verify that the 371A can send data to a connected plotter device.

1. Connect a HPGL-compatible plotter (with an input buffer of at least 8 K) to the
    PLOTTER INTERFACE PORT on the rear panel of the 371A.

2. Plot the display in one of two modes:
    A. Characteristic curve only: display a characteristic curve, then hold down the cursor
        SHIFT button and press the GPIB PLOT button.
    B. Entire display (text and curve): display a characteristic curve, then press the GPIB
        PLOT button on the front-panel.

    In either case, output to the plotter begins when the GPIB PLOT button is pressed.

3. To stop output to the plotter, press the GPIB PLOT button once again.

*By completing these operating exercises you have sufficient experience to be able to
work through the measurement exercises provided next in this chapter.*

*In the the measurement exercises, we provide demonstrations using the dot, window,
and f line cursors, as well as additional demonstrations using the front-panel
controls to perform setups, memory exercises, and to use other features of the 371A.*

MEASUREMENT EXERCISES

This section demonstrates how to use the 371A to perform specific measurements. Here we describe how to set controls, make device connections, and interpret the displays for diode, bipolar transistors, and power MOSFET measurements. The following exercises are provided:

- measuring forward resistance characteristics of a diode
- measuring breakdown voltage characteristics of a diode
- displaying collector current versus collector/emitter voltage characteristics of a bipolar transistor
- comparing an acquired curve with a reference curve
- measuring gain of a bipolar transistor
- measuring saturation voltage of a bipolar transistor
- measuring breakdown voltage of a bipolar transistor
- displaying drain current versus drain source voltage characteristics of a power MOSFET
- measuring forward admittance of a power MOSFET

In the measurement examples, we will demonstrate using the dot, window, and f line cursors, as well as using other controls and 371A features that are not covered in the "Operating Exercises" earlier in this chapter.

Effects on Device Characteristics

Illustrations of displayed waveforms are provided in the following procedures. When attempting to duplicate the displays in the course of a procedure, remember that device characteristics differ and the displays depicted here will likely be different than the displayed characteristics for your DUT.

Guidelines for Using Measurement Exercises

You can use this section in one of two ways:

1. As a training exercise to familiarize yourself with the general principles of measurement methodology. You can easily progress from one exercise to the next. Start at the beginning and perform all measurement exercises in sequence.

2. To perform a specific exercise. Because each exercise contains related setup information or references to setup information, you can choose to perform only the exercise of interest.

Saving the Initial (Default) Setup

Throughout the following procedures you will be asked to "initialize" the 371A; that is, to restore the instrument to its power-up (default) control settings. One way to initialize the 371A is to cycle power off, then back on. But that's not the best way. The best way is to save the power-up settings in memory and recall them from memory as directed in the procedures. Refer back to "Powering-Up the 371A and Storing Power-Up Default Settings" earlier in this chapter for instructions on how to save settings.

Diode Measurement Exercises

These procedures demonstrate how to measure the forward resistance and breakdown voltage characteristics of a power diode.

Measuring Forward Resistance Characteristics of a Diode

This procedure demonstrates how to measure the forward resistance of a diode. The dot and f line cursors are used in this demonstration.

1. Open the protective cover on the test fixture unit.

   If using the A1005 test adapter, perform Step 2. If using patch cords, perform Step 3.

   NOTE

   For details about the patch and adapter panels, refer to the discussion under "Test Fixture Unit" in Chapter 2: General Operation.

2. If using an A1005 test adapter, proceed as follows:
   A. Insert the test adapter into the test adapter connector on the adapter panel.
   B. Mount the diode in the test adapter (anode lead connected to top end of test adapter).
   C. Connect the patch cords between connectors on the patch and adapter panels as shown in Figure 3-4.
   D. Close the protective cover.
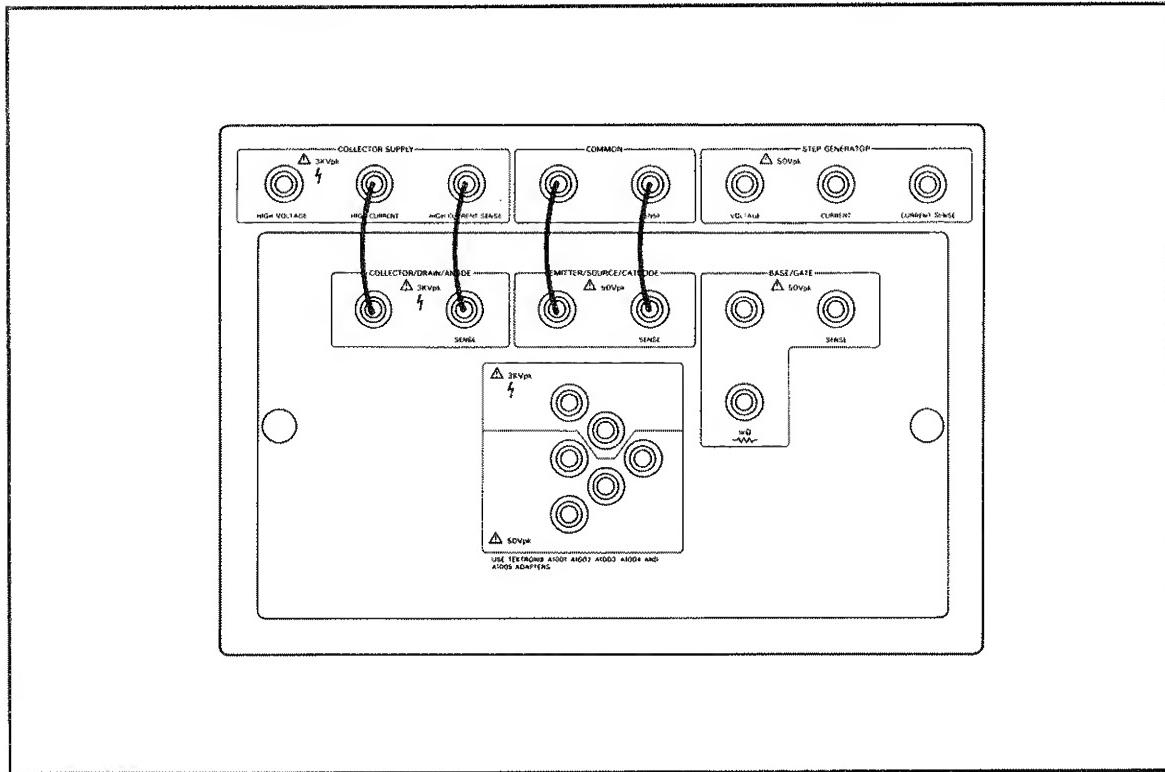
Figure 3-4. Adapter panel and patch panel connections for measuring diode forward resistance.

3. If an A1005 test adapter is not available and you are using patch cords with clips, perform the following:

NOTE

When using patch cords with clips, ensure that neither the patch cord clips nor the DUT leads contact the chassis. Grounding patch cord clips or DUT leads to the chassis may damage the DUT or 371A circuit components.

A. Remove the adapter panel as described under "Test Fixture Unit" in Chapter 2: General Operation.

B. Using patch cords with alligator clips, connect the diode to the patch panel as follows:

  • Connect the COLLECTOR SUPPLY HIGH CURRENT and COLLECTOR SUPPLY HIGH CURRENT SENSE to the anode end of the diode.

  • Connect the COMMON and COMMON SENSE to the cathode end of the diode.

C. Close the protective cover on the test fixture unit.

4. Observe that the memory location is set to 1, then press the setup RECALL button to initialize the 371A. If you have not saved the initial setup in memory, refer to "Saving the Initial (Default) Setup" earlier in this chapter.

5. Set the 371A controls as follows:

   A. Set the VERTICAL CURRENT/DIV and HORIZONTAL VOLTS/DIV to appropriate values depending on the forward current and forward voltage rating of the diode.

   B. Disable the step generator by holding down the cursor SHIFT button and then pressing the STEP MULTI .1X button.

6. Set the collector supply HIGH CURRENT breaker to the ENABLED position.

7. Rotate the collector supply VARIABLE knob slowly clockwise.

   The dot traces the forward characteristic of the diode.

8. Set the collector supply VARIABLE knob so that forward current flows through the diode, then press the measurement SWEEP button.

   The collector supply voltage is increased from 0% to the value set by the collector supply VARIABLE knob, resulting in a series of dots representing the forward characteristic of the diode as shown in Figure 3-5.
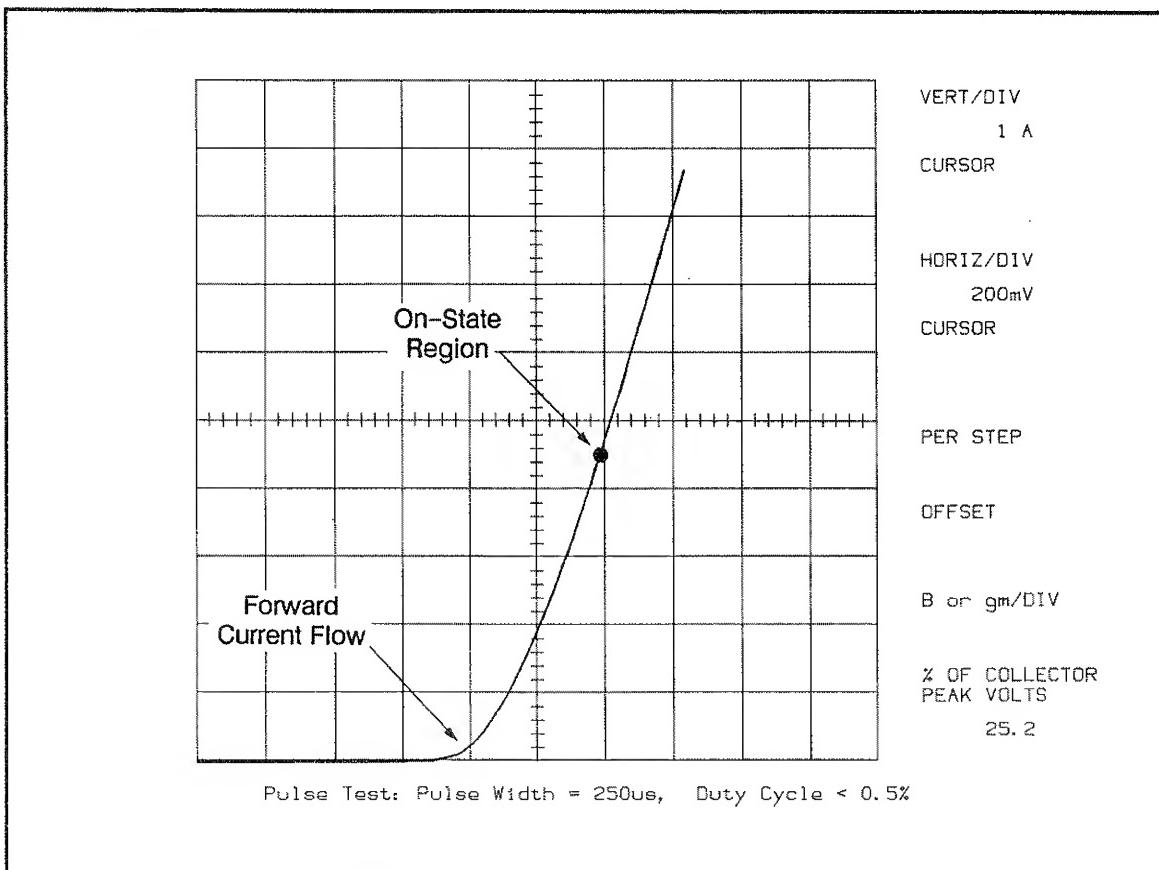
Figure 3-5. Sweep mode display of the forward characteristics of a diode.

9. Select the dot cursor using the up cursor selection button.

   Observe that a high-intensity dot is displayed on the origin of the characteristic curve. If the dot does not appear, adjust the NON STORE/STORE/VIEW INTENSITY control.

10. Move the dot cursor into the on-state region using the up, down, left, and right cursor position buttons.

11. Select the ƒ line cursor with the up cursor button.

   If the ƒ line cursor does not appear, adjust the READOUT/CURSOR INTENSITY control.

12. Change the slope of the ƒ line cursor using the up, down, left, right cursor position buttons until the cursor is tangent to the curve as shown in Figure 3-6.
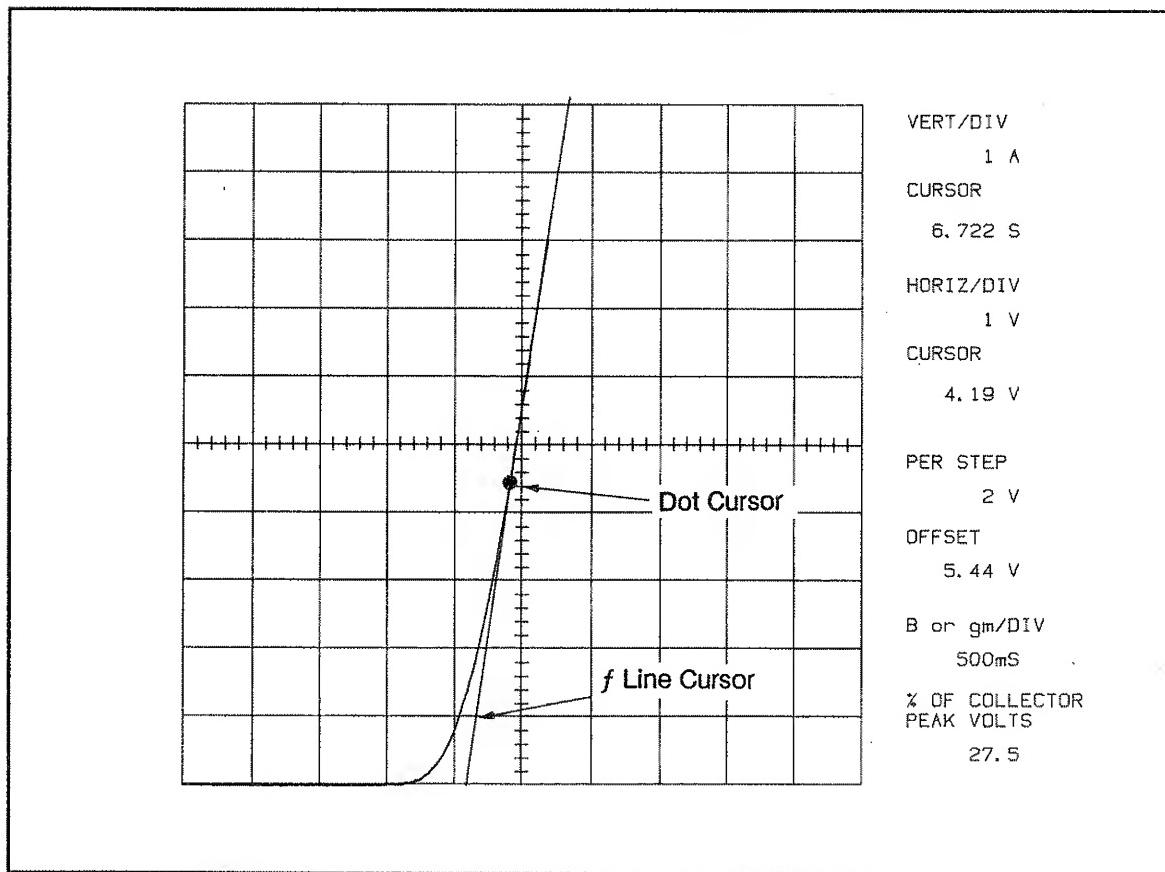
Figure 3-6. Using ƒ line cursor to measure forward resistance of a diode.

13. Observe that the CURSOR (f:1/grad) readout area indicates the on-state resistance of the diode.

14. Set the collector supply HIGH CURRENT breaker to the DISABLED position.

15. If you are continuing with the measurement examples, proceed with the next exercise "Measuring Breakdown Voltage Characteristics of a Diode."

    If you are finished testing at this point, open the protective cover, remove the diode, and power down the 371A.

Measuring Breakdown Voltage Characteristics of a Diode

The dot cursor is used in this demonstration.

> CAUTION

> *When using the A1005 test adapter, do not exceed its maximum voltage listed on the adapter. The plastic adapter can be damaged by excessive heat resulting from too high a voltage. If you expect this voltage to be exceeded, connect the DUT directly to the patch panel with patch cords as described in Step 4, below. For additional information refer to "Test Fixture Unit" in Chapter 2: General Information.*

1. Set the collector supply HIGH CURRENT breaker to the DISABLED position and open the protective cover on the test fixture unit.

2. If using the A1005 test adapter, perform Step 3. If using patch cords with clips, perform Step 4.

> *NOTE*

> *For details about the adapter and patch panels, refer to the discussion under "Test Fixture Unit" in Chapter 2: General Information.*

3. If using an A1005 test adapter, proceed as follows:
   A. Insert the A1005 test adapter into the test adapter connector on the adapter panel.
   B. Mount the diode in the test adapter with the anode lead to the C terminal at the top of adapter.
   C. Connect the patch cords between connectors on the adapter and patch panels as shown in Figure 3-7.
   D. Close the protective cover.
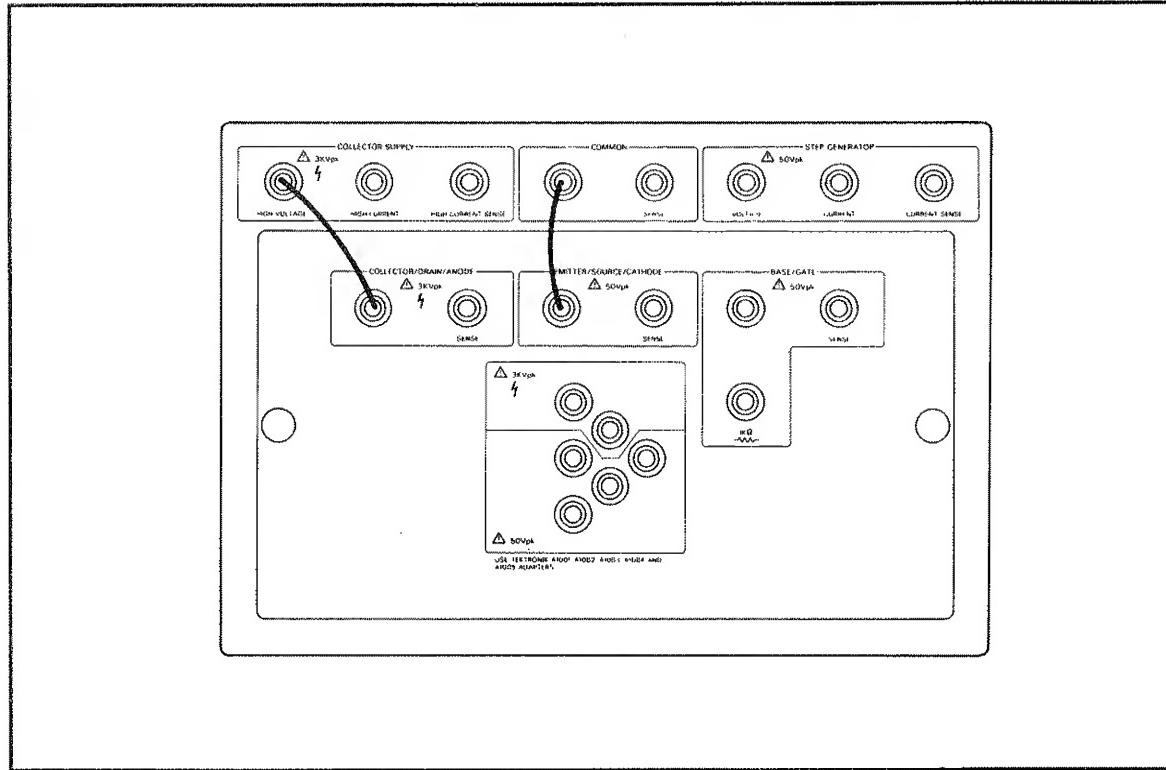
Figure 3-7. Adapter panel and patch panel connections for measuring diode breakdown voltage.

4. If an A1005 test adapter is not available and you are using patch cords, perform the following:

    A. Remove the adapter panel as described under "Test Fixture Unit" in Chapter 2: General Operation.

    B. Using patch cords with alligator clips, connect the diode to the patch panel as follows:

        •   Connect COLLECTOR SUPPLY HIGH VOLTAGE to the anode end of the diode.

        •   Connect COMMON to the cathode end of the diode.

    C. Close the protective cover on the test fixture unit.

5. Initialize the 371A by setting the memory location to 1 and then pressing the memory RECALL button. If you have not saved the initial setup in memory, refer to "Saving the Initial (Default) Setup" earlier in this chapter.

   Set the 371A controls as follows:

   A. Collector supply peak power watts to 3 W.

   B. Collector supply POLARITY to INVERT

   C. VERTICAL CURRENT/DIV and HORIZONTAL VOLTS/DIV to appropriate values for the reverse current and reverse breakdown voltage of the selected diode.

   D. Disable the step generator by holding down the cursor SHIFT button and then pressing the STEP MULTI .1X button.

   E. Press the display INVERT button (the INVERT LED lights).

6. Set the collector supply HIGH VOLTAGE breaker to the ENABLED position.

7. Rotate the collector supply VARIABLE knob slowly clockwise to trace the reverse characteristic curve of the diode.

8. If the display loops, adjust the LOOPING COMPENSATION control.

9. Rotate the collector supply VARIABLE knob farther clockwise to make breakdown current flow. You should see a display similar to the one shown in Figure 3-8.

10. Use the up cursor button to select the dot cursor, and use the up, down, left, and right cursor position buttons to move the cursor to the desired breakdown current level on the curve.

    The vertical CURSOR (f: 1/grad) readout gives the current level and the horizontal CURSOR (f: 1/intercept) readout gives the breakdown voltage as shown in Figure 3-8.

11. Set the collector supply HIGH VOLTAGE to the DISABLED position.

12. Open the protective cover and remove the diode, test adapter (if used) and patch cords.

    Reinstall the adapter panel, if removed.

The 371A is now ready for another operation.

```
                                              VERT/DIV
                                                 100uA
                                              CURSOR
                                                -468uA

                                              HORIZ/DIV
                                                 200  V
                                              CURSOR
                                                -1520 V

                                              PER STEP

                                              OFFSET


                                              B or gm/DIV


                                              % OF COLLECTOR
                                              PEAK VOLTS
                                                 69.8
```
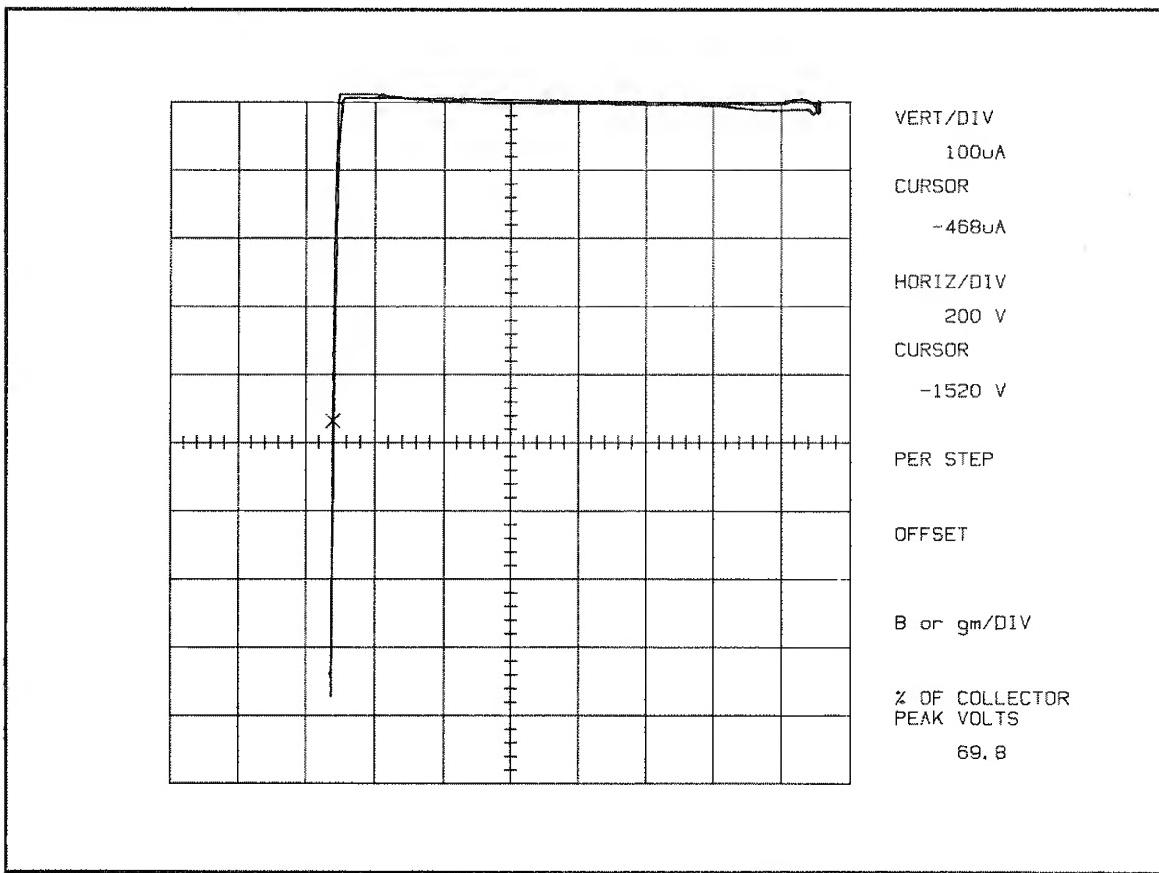
Figure 3-8. Diode breakdown voltage and current level.

Bipolar Transistor Measurement Exercises

Bipolar transistor measurement exercises demonstrate the following:

• displaying collector current versus collector/emitter voltage

• comparing an acquired curve with a reference curve

• measuring gain

• measuring saturation voltage

• measuring breakdown voltage

Displaying Collector Current Versus Collector/Emitter Voltage

This exercise demonstrates how to display collector current versus collector/emitter voltage of a bipolar transistor using the window cursor.

1. Obtain a high-power bipolar transistor.

2. Set the collector supply HIGH VOLTAGE and HIGH CURRENT breakers to their DISABLED position.

3. If using a test adapter, perform Step 4. If using patch cords, perform Step 5.

NOTE

For details about the adapter and patch panels, refer to "Test Fixture Unit" in Chapter 2: General Operation.

4. Use either the A1002 or A1003 test adapter, whichever is best suited for the type of transistor selected. Proceed as follows:

    A. Mount the transistor in the test adapter.
    B. Insert the test adapter into the test adapter connector on the adapter panel.
    C. Connect patch cords between adapter and patch panels as shown in Figure 3-9.
    D. Close the protective cover.

5. If using patch cords, perform the following:

    A. Remove the adapter panel as described under "Test Fixture Unit" in Chapter 2: General Operation.
    B. Using patch cords with alligator clips, connect the transistor to the patch panel connectors as follows:

    *   Using two red patch cords, connect one cord to the COLLECTOR SUPPLY HIGH CURRENT connector, and the other cord to the COLLECTOR SUPPLY HIGH CURRENT SENSE connector.
    *   Connect the alligator ends of both red patch cords to the collector lead of the transistor.
    *   Using two black patch cords, connect one cord to the COMMON connector and the other cord to the COMMON SENSE connector.
    *   Connect the alligator ends of both black patch cords to the emitter lead of the transistor.
    *   Using two black patch cords, connect one cord to the STEP GENERATOR CURRENT connector and the other cord to the STEP GENERATOR CURRENT SENSE connector.
    *   Connect the alligator ends of both black patch cords to the base lead of the transistor.

    C. Close the protective cover on the test fixture unit. Check the location of the transistor leads to ensure that no short circuits exist to other leads or the inside of the test fixture unit.
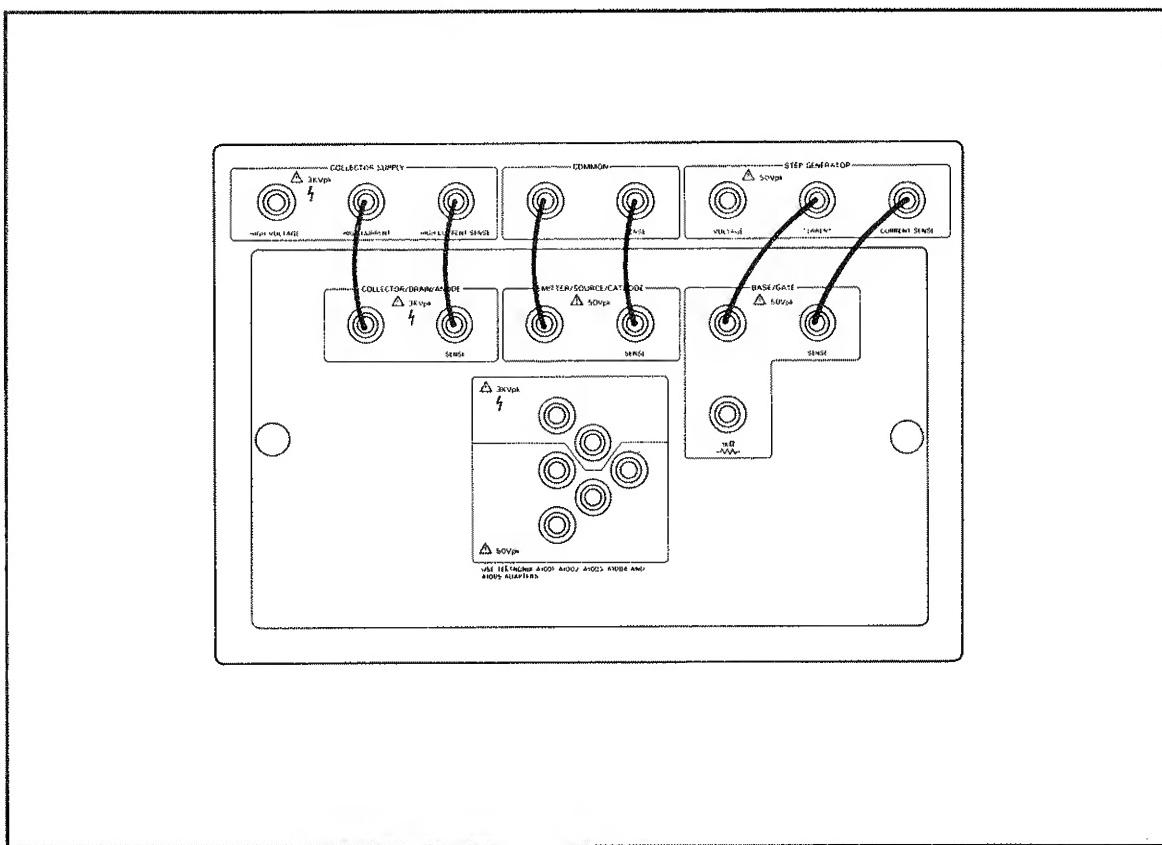
Figure 3-9. Adapter panel and patch panel connections for measuring bipolar transistor characteristics.

6. Set the memory location to 1, then press the setup RECALL button to initialize the 371A. If you have not saved the initial setup in memory, refer to "Saving the Initial (Default) Setup" earlier in this chapter.

7. Set the 371A controls as follows:

    A. Collector supply polarity to NPN+ or PNP- depending on the type of transistor used.

    B. VERTICAL CURRENT/DIV to about 1/10 of the rated collector (pulse) current.

    C. Step generator NUMBER OF STEPS to 5.

8. Set the collector supply HIGH CURRENT breaker to the ENABLED position.

9. Rotate the collector supply VARIABLE knob slowly clockwise until the lowest dot intercepts the horizontal axis at about ten divisions.

10. Press the NUMBER OF STEPS up button four times.

11. Observe that the number of dots displayed increases each time the button is pressed.

12. Rotate the STEP/OFFSET AMPLITUDE knob until the dots are separated by about one division.

13. Press the STEP MULTI . 1X button and observe that the collector current decreases as the step amplitude is reduced to one-tenth of its previous setting.

14. Press the STEP MULTI .1X button again to resume normal operation.

15. Press the measurement SWEEP button.

    In a few seconds, the collector current versus collector/emitter voltage characteristic curve will be displayed similar to the curve shown in Figure 3-10.

16. If you are continuing with the transistor measurement examples, proceed with the next exercise "Comparing an Acquired Curve With A Reference Curve."

    If you are finished testing at this point, open the protective cover, and remove the transistor and patch cords. Reinstall the adapter panel, if removed.

The 371A is now ready for another operation.
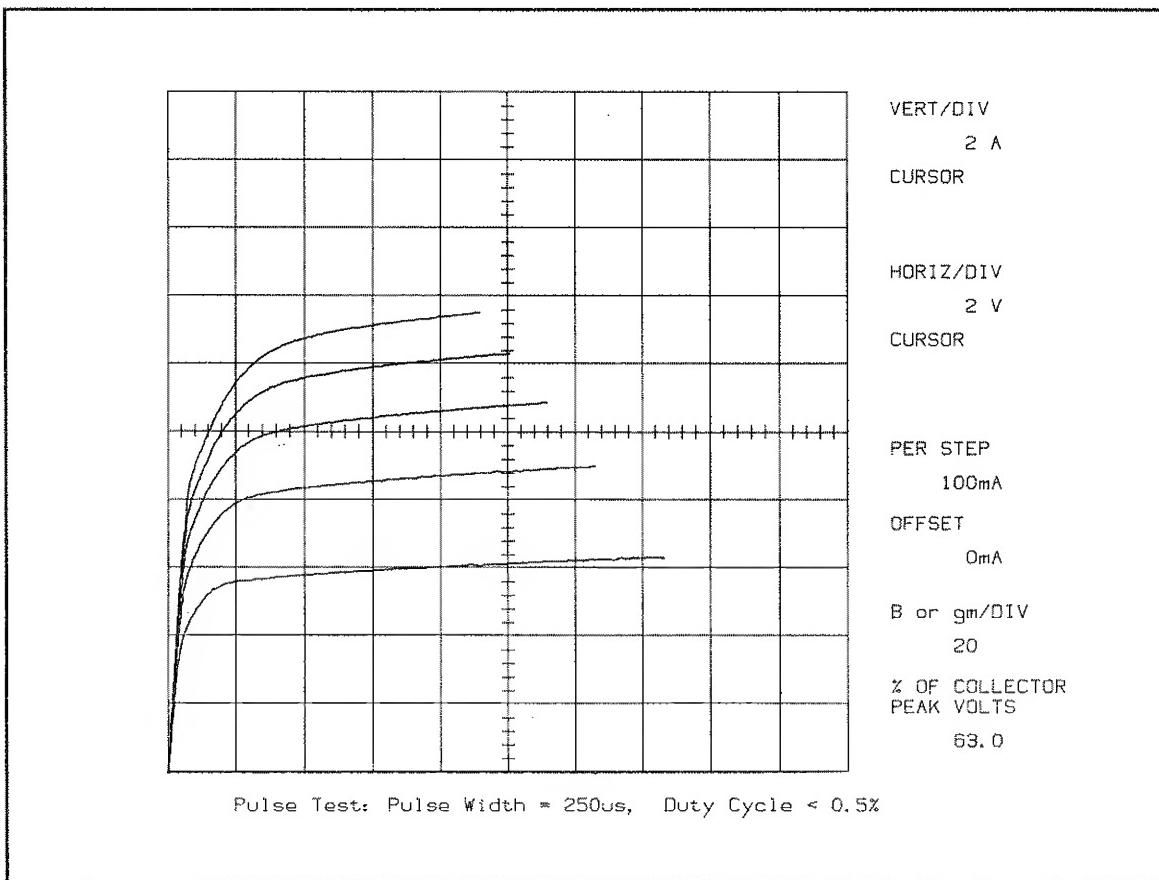
Figure 3-10. Collector current versus collector/emitter voltage characteristic curve.

Comparing an Acquired Curve with a Reference Curve

This procedure demonstrates how to compare an acquired curve with a reference curve.

1. Acquire a characteristic curve by performing all steps of the preceding exercise "Displaying Collector Current Versus Collector/Emitter Voltage."

2. Change the memory location to 2, then press the display ENTER button.

   Observe that message ENTER COMPLETE is displayed on the screen in the message area.

   The characteristic curve on the screen is now stored in memory location 2. Press the display VIEW button to display the stored curve at any time.

3. Press the display STORE button again, then press the measurement SWEEP button.

4. The 371A displays the collector current versus collector/emitter voltage curve as shown earlier in Figure 3-10.

5. Turn the REF INTENSITY control throughout its range. Observe that only the brightness of the reference curve is varied.

6. Press the display INVERT button and the REF button again to resume normal operation.

7. Press the measurement SWEEP button again to display the characteristic curve of collector current versus collector/emitter voltage.

8. If you are continuing with the transistor measurement examples, proceed with the next exercise "Measuring Gain of a Bipolar Transistor."

   If you are finished testing at this point, open the protective cover, and remove the transistor and patch cords. Reinstall the adapter panel, if removed.

The 371A is now ready for another operation.

Measuring Gain of a Bipolar Transistor

To measure the gain of a bipolar transistor, perform the following steps.

1. Acquire a characteristic curve by performing all steps of the preceding exercise "Displaying Collector Current Versus Collector/Emitter Voltage."

2. Position the window cursor as follows:
   A. Use the cursor select up button to select the window cursor with the bottom left intensity dot.
   B. Use the cursor position up, down, left, and right buttons to position the intensity dot, at any point on the characteristic curve.
   C. Use the cursor select up button to select the window cursor with the top right intensity dot.
   D. Press the cursor left position button to narrow the cursor window into a straight vertical line as shown in Figure 3-11.

E.   Use the up or down cursor position buttons to position the bright dot of the window cursor on an adjacent characteristic curve as shown in Figure 3-11.

The number now display in the ß or gm/div readout area is the h$_{fe}$ (gain) of the DUT.

3.   Set the collector supply HIGH CURRENT breaker to the DISABLED position.

4.   If you are continuing with the transistor measurement examples, proceed with the next exercise "Measuring Saturation Voltage."

If you are finished testing at this point, open the protective cover, and remove the transistor and patch cords. Reinstall the adapter panel, if removed.

The 371A is now ready for another operation.

VERT/DIV
   500mA
CURSOR
    2100mA

HORIZ/DIV
    1 V
CURSOR
    4.41 V

PER STEP
    2mA

OFFSET
    0.00mA

B or gm/DIV
    432

% OF COLLECTOR
PEAK VOLTS
    32.0

Pulse Test: Pulse Width = 250us,   Duty Cycle < 0.5%
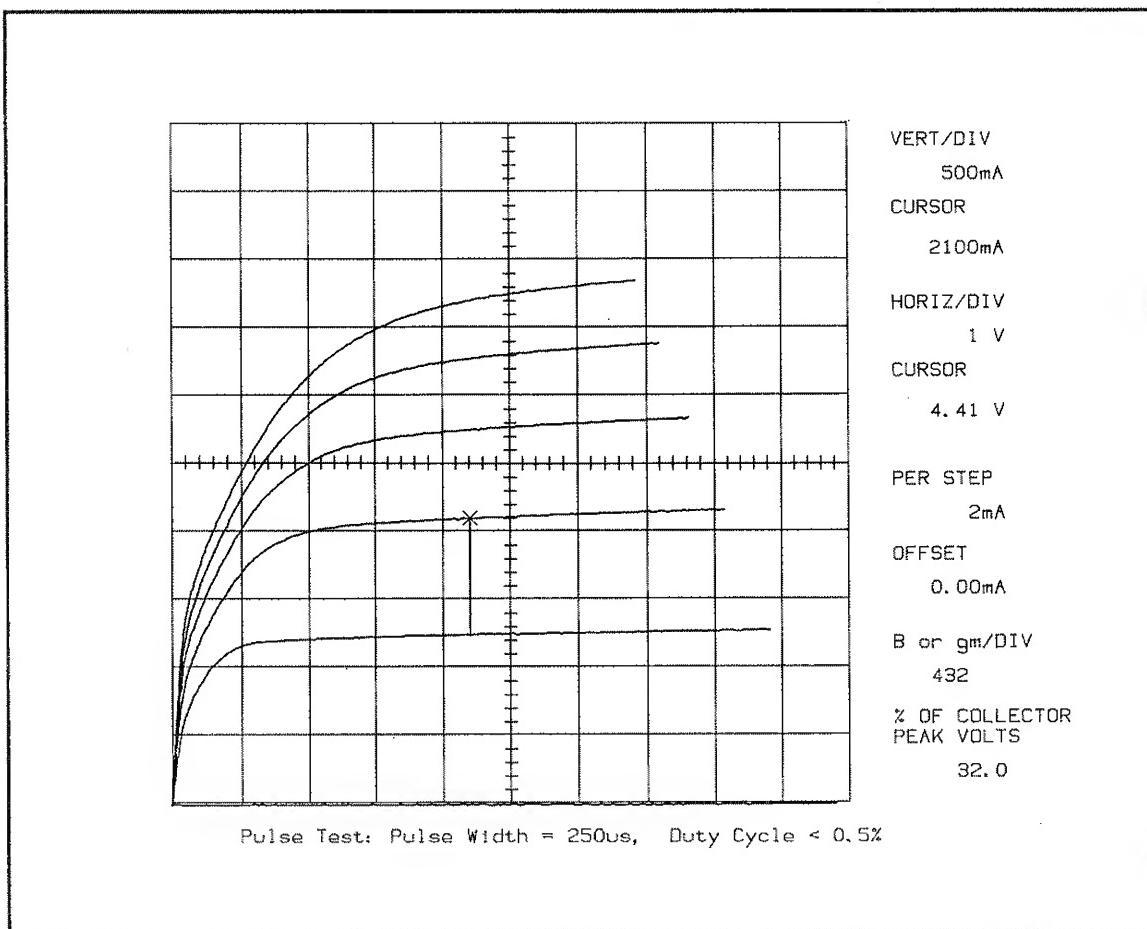
Figure 3-11. Using the window cursor to calculate h$_{fe}$ of a bipolar transistor.

Measuring Saturation Voltage

This procedure demonstrates how to measure the saturation voltage of an NPN bipolar transistor at 10 A I_C and 2 A I_B.

1. Obtain a high-power bipolar transistor. (For the following procedures we used an NPN bipolar transistor with a BV_{CEO} rating of 1500 V.)

2. Install the transistor as described in Steps 3 - 5 of the preceding exercise, "Displaying Collector Current Versus Collector/Emitter Voltage."

3. Set the memory location to 1, then press the setup RECALL button to initialize the 371A. If you have not saved the initial setup in memory, refer to "Saving the Initial (Default) Setup" earlier in this chapter.

4. Set the 371A controls as follows:

   A. Step generator:
      NUMBER OF STEPS to 0
      STEP OFFSET AMPLITUDE to 500 mA/STEP.

   B. Display:
      VERTICAL CURRENT/DIV to 2 A
      HORIZONTAL VOLTS/DIV to 100 mV COLLECTOR

5. Close the protective cover, then set the collector supply HIGH CURRENT breaker to the ENABLED position.

6. Set the OFFSET readout (I_B) to 2000 mA using the step generator up and down OFFSET buttons.

7. Increase the collector supply VARIABLE setting until the dot rises above the 10 A graticule line, which is the center horizontal graticule line.

8. Press the measurement SWEEP button to display a curve similar to the curve shown in Figure 3-12.

9. Use the cursor selection up and down buttons to select the dot cursor.

10. Use the cursor position up, down, left, and right buttons to move the dot cursor to the 10 A level on the curve.

11. Read the V_{CE} (saturation) value in the HORIZ/DIV CURSOR readout area.

12. Set the collector supply HIGH CURRENT breaker to the DISABLED position,

```
                                              VERT/DIV
                                                   2 A
                                              CURSOR
                                                10,00 A

                                              HORIZ/DIV
                                                  100mV
                                              CURSOR
                                                 575mV

                                              PER STEP
                                                 500mA
                                              OFFSET
                                                2000mA

                                              B or gm/DIV
                                                  5,0
                                              % OF COLLECTOR
                                              PEAK VOLTS
                                                 30,6

         Pulse Test: Pulse Width = 250us,   Duty Cycle < 0.5%
```
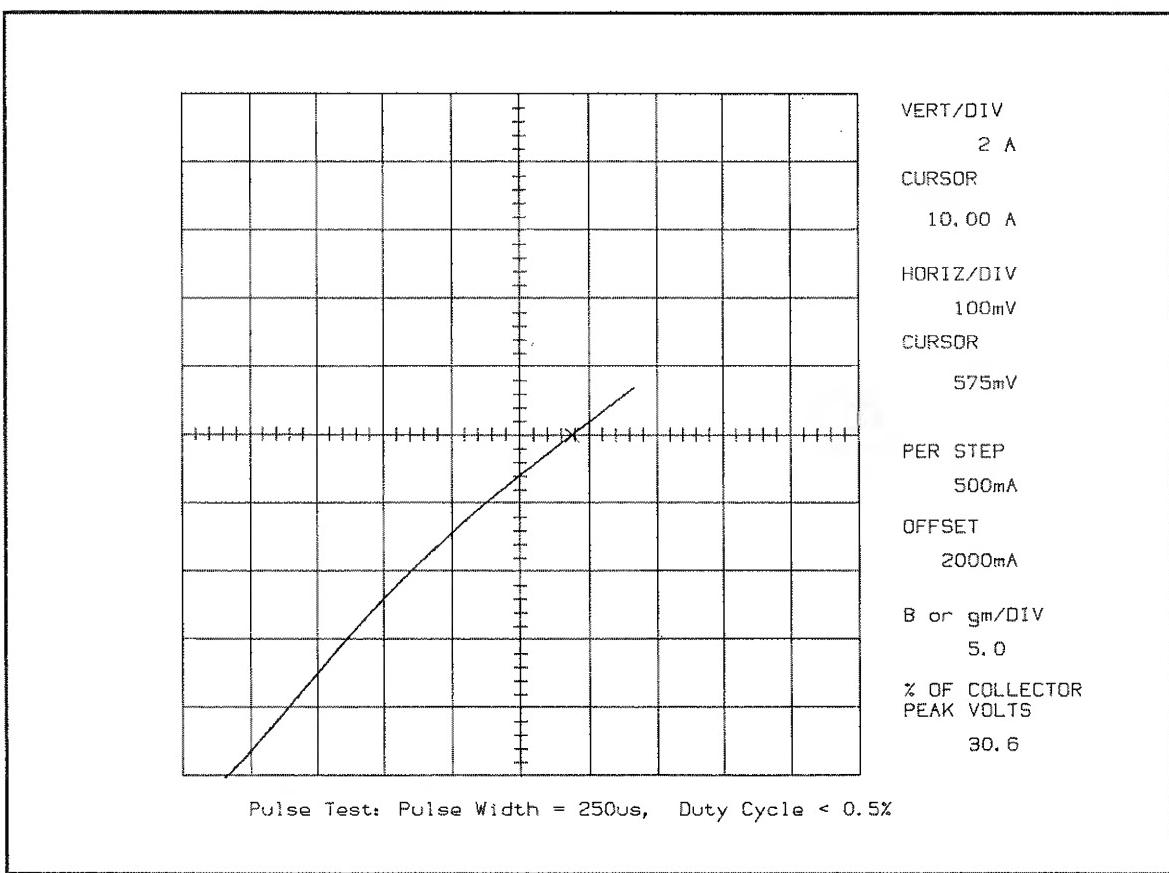
Figure 3-12. V$_{CE}$ (saturation) curve for a bipolar transistor.

13. If you are continuing with transistor measurement examples, proceed with the next exercise, "Measuring Breakdown Voltage."

     If you are finished testing at this point, open the protective cover, and remove the transistor and patch cords. Reinstall the adapter panel if removed.

The 371A is now ready for another operation.

Measuring Breakdown Voltage

This procedure demonstrates how to measure the collector/emitter breakdown voltage of a bipolar transistor.

1. Obtain a high-power bipolar transistor. (For the following procedures we used an NPN bipolar transistor with a BV$_{CEO}$ rating of 1500 V.)

2. Set the collector supply HIGH VOLTAGE and HIGH CURRENT breakers to the DISABLED position and open the protective cover on the test fixture unit.

3. If using a test adapter, perform Step 4. If using patch cords, perform Step 5.

NOTE

For details about the adapter and patch panels, refer to the discussion under "Test Fixture Unit in Chapter 2: General Operation.

4. Use either the A1002 or A1003 test adapter, whichever is best suitable for the type of transistor selected. Proceed as follows:

   A. Mount the transistor in the test adapter.

   B. Insert the test adapter into the test adapter connector on the adapter panel.

   C. Connect the patch cords between connectors on the adapter and patch panels as illustrated in Figure 3-13.

   D. Close the protective cover.

(The dashed-line connection is not made until step 12.)
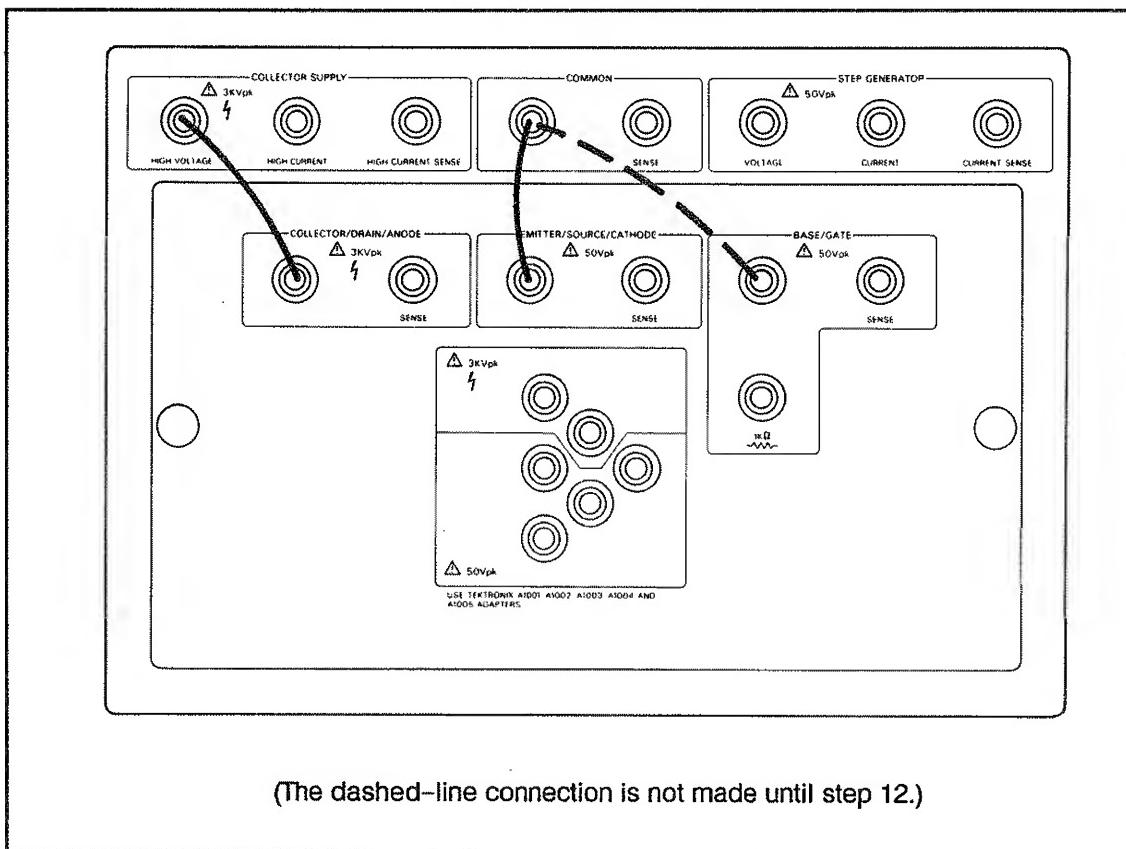
Figure 3-13. Adapter panel and patch panel connections for measuring breakdown voltage characteristics of a bipolar transistor.

5. If using patch cords, perform the following:

   A. Remove the adapter panel as described under "Test Fixture Unit" in Chapter 2 General Operation.

   B. Using patch cords with alligator clips, connect the transistor to the patch panel as follows:

   - Connect a red patch cord to the COLLECTOR SUPPLY HIGH VOLTAGE connector. Connect the alligator end of the patch cord to the collector lead of the transistor.

   - Connect a black patch cord to the COMMON connector. Connect the alligator end of the patch cord to the emitter lead of the transistor.

   - Close the protective cover on the test fixture unit.

   - Check the location of the transistor leads to ensure that no short circuits exist to other leads or to the inside of the test fixture unit.

6. Set the memory location to 1, then press the setup RECALL button to initialize the 371A. If you have not saved the initial setup in memory, refer to "Saving the Initial (Default) Setup" earlier in this chapter.

7. Set the collector supply HIGH VOLTAGE breaker to the ENABLED position.

8. Set other 371A controls as follows:

   A. Collector supply peak power watts to 3 W

   B. Display HORIZONTAL VOLTS/DIV to 200 V COLLECTOR

9. Slowly increase the collector supply VARIABLE until device breakdown is indicated on the 371A display.

NOTE

Use the front-panel LOOPING COMPENSATION control to compensate for any displayed looping. Refer to the explanation under the "Collector Supply Controls "in Chapter 4: Controls, Indicators, and Connectors for details about looping.

10. Press the display REF button to store the BV_{CEO} (breakdown) curve in memory.

11. Set the collector supply HIGH VOLTAGE breaker to DISABLED.

    Observe that the reference curve remains displayed. You may have to adjust the REF INTENSITY knob to display the reference curve.

12. Open the protective cover, and use another patch cord to connect the COMMON and the BASE/GATE terminals on the adapter panel, as indicated by the dashed line shown Figure 3-12. (The COMMON connector now has two patch cords attached. One connects to the EMITTER/SOURCE/CATHODE connector; the other connects to the BASE/GATE connector of the adapter panel.)

13. Close the protective cover.

14. Set the collector supply HIGH VOLTAGE breaker to ENABLED.

15. Slowly increase the collector supply VARIABLE until breakdown occurs.

16. Use the cursor select buttons to select the dot cursor.

17. Use the cursor position buttons to move the dot cursor into the breakdown region.

18. The breakdown voltage (BV_{CES}) is displayed in the horizontal CURSOR (f: 1/intercept) readout area on the CRT display.

19. Observe that the stored BV_{CEO} curve in the reference memory and the BV_{CES} curve in store mode are displayed on the CRT, as shown in Figure 3-14.

VERT/DIV
100uA
CURSOR
502uA

HORIZ/DIV
200 V
CURSOR
1782 V

PER STEP
2uA
OFFSET
0.00uA

B or gm/DIV
50
% OF COLLECTOR
PEAK VOLTS
74.3
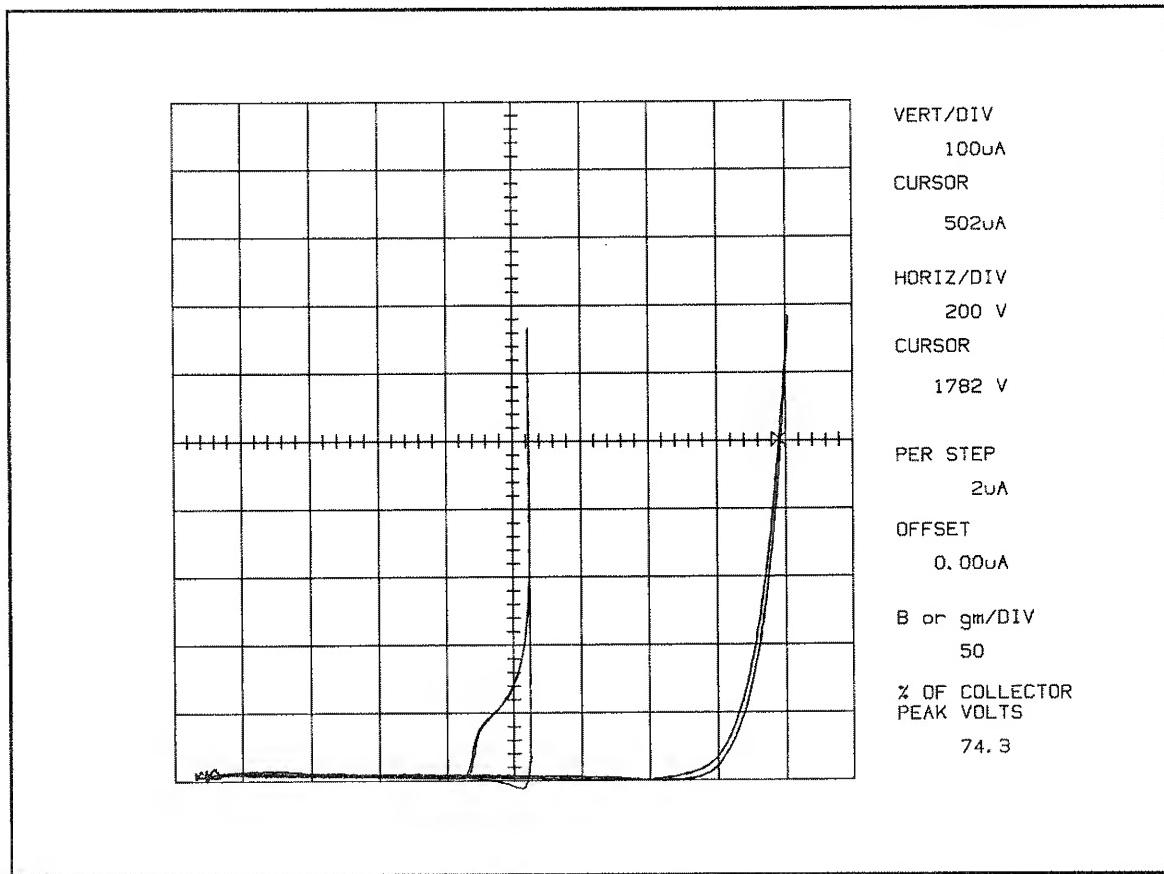
Figure 3-14. Display of the BV_{CEO} and BV_{CES} breakdown measurements with reference function.

20. Set the collector supply HIGH VOLTAGE breaker to the DISABLED position.

21. This completes the transistor measurement exercises.

    Open the protective cover and remove the transistor and patch cords. Reinstall the adapter panel if removed.

The 371A is now ready for other test applications.

Power MOSFET Measurement Exercises

The techniques for measuring the operating characteristics of power MOSFETS are similar to the techniques used for bipolar transistors. Table 3-3 compares the equivalent characteristics between the two semiconductor devices.

Table 3-3
Bipolar Transistor/MOSFET Characteristic Comparison

Bipolar Transistor	MOSFET
Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)}CES$	$V_{(BR)}DSS$
V_{CBO}	V_{DGR}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE}(ON)$	$V_{GS}(th)$
$V_{CE}(SAT)$	$V_{DS}(on)$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{ce}(sat) = \dfrac{V_{CE}(sat)}{I_C}$	$r_{ds}(on) = \dfrac{V_{DS}(on)}{I_D}$
V_{EC}	V_{SD}

These procedures demonstrate how to

• display drain current versus drain/source voltage characteristics

• measure forward admittance

Displaying Drain Current versus Drain/Source Voltage Characteristics

This procedure demonstrates how to display drain current versus drain/source voltage of a MOSFET.

1. Obtain an N-channel enhancement-type power MOSFET.

2. Set the collector supply HIGH VOLTAGE and HIGH CURRENT breakers to their DISABLED position and open the protective cover on the test fixture unit.

3. If using a test adapter, perform Step 4. If using patch cords, perform Step 5.

NOTE

For details about the adapter and patch panels, refer to the discussion under "Test Fixture Unit" in Chapter 2: General Operation.

4. Use either the A1002 or A1003 test adapter (standard accessories), whichever is best suitable for the type of MOSFET selected. Proceed as follows:

    A. Mount the MOSFET in the test adapter.
    B. Insert the test adapter into the test adapter connector on the adapter panel.
    C. Connect the patch cords between connectors on the adapter and patch panels as shown in Figure 3-15.
   D. Close the protective cover.
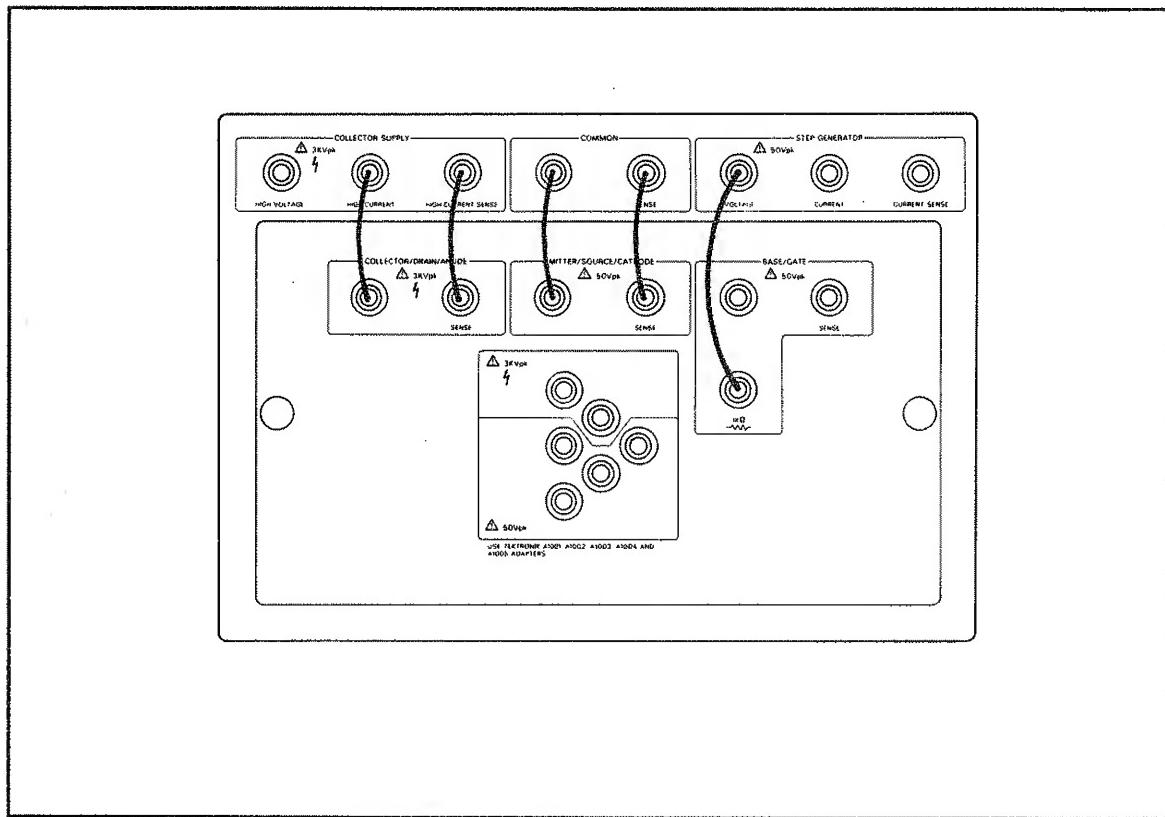
Figure 3-15. Adapter panel and patch panel connections for measuring power MOSFET characteristics.

NOTE

*Kelvin sensing is used in this measurement example because of the high
current levels flowing through the DUT. Thus sensing is done through the 1
kΩ resistor inside the adapter panel. This helps to prevent oscillations.*

5. If using patch cords, perform the following:

    A. Remove the adapter panel as described under "Test Fixture Unit" in Chapter 2:
        General Operation.

    B. Using patch cords with alligator clips, connect the MOSFET to the patch panel
        connectors as follows:

        • Using two red patch cords, connect one cord to the COLLECTOR SUPPLY HIGH
          CURRENT connector, and the other cord to the COLLECTOR SUPPLY HIGH
          CURRENT SENSE connector.

        • Connect the alligator ends of both red patch cords to the drain lead of the
          MOSFET.

        • Using two black patch cords, connect one cord to the COMMON connector and
          the other cord to the COMMON SENSE connector.

        • Connect the alligator ends of both black patch cords to the source lead of the
          MOSFET.

        • Connect an alligator patch cord to the STEP GENERATOR VOLT@GE connector
          and the other end to the gate lead of the MOSFET.

        • Connect the alligator end of the black patch cord to the base lead of the
          transistor.

NOTE

*It may be necessary for you to add a 1 kΩ resistor in series with the base lead
to stabilize the device.*

    C. Close the protective cover on the test fixture unit. Check the location of the
        transistor leads to ensure that no short circuits exist to other leads or to the inside of
        the test fixture unit.

NOTE

*Kelvin sensing is used in this measurement example because of the high
current levels flowing through the DUT. The 1 kΩ resistor in series with the
STEP GENERATOR VOLTAGE connector helps prevent oscillation.*

6. Set the memory location to 1, then press the setup RECALL button to initialize the 371A.
    If you have not saved the initial setup in memory, refer back to "Saving the Initial
    (Default) Setup" earlier in this chapter.

7. Set other 371A controls as follows:

   A. Collector supply PEAK POWER WATTS to 3 KW or 300 W depending on the MOSFET power rating

   B. Step generator
      SOURCE to VOLTAGE
      NUMBER OF STEPS to 0
      STEP MULTI .1X to ON
      STEP/OFFSET AMPLITUDE to 500 mV (with STEP MULTI .1X on)

   C. VERTICAL CURRENT/DIV to about 1/10 of the rated drain (pulse current)

   D. HORIZONTAL VOLTS/DIV to 2 V COLLECTOR

8. Use the cursor select up button to select the dot cursor.

9. Set the collector supply HIGH CURRENT breaker to the ENABLED position.

10. Rotate the collector supply VARIABLE knob slowly clockwise and move the displayed dot about ten division to the right.

11. Press the OFFSET up button until there is a change in the vertical CURSOR (f: 1/grad) readout, indicating the onset of drain current flow.

12. Press the NUMBER of STEPS up button five times.

13. Observe that the number of dots displayed increases each time the button is pressed.

14. Press the measurement SWEEP button

    In about 15 seconds, drain current versus drain-source voltage characteristic curves will be displayed similar to those shown in Figures 3-16 and 3-17.

15. Set the collector supply HIGH CURRENT breaker to the DISABLED position.

16. If you are continuing with MOSFET measurement examples, proceed with the next exercise "Measuring Forward Admittance of a Power MOSFET."

    If you are finished testing at this point, open the protective cover, and remove the MOSFET and patch cords. Reinstall the adapter panel if removed.

The 371A is now ready for another operation.

VERT/DIV
          2 A
CURSOR

HORIZ/DIV
          2 V
CURSOR

PER STEP
        500mV
OFFSET
        3.50 V

B or gm/DIV
          4 S
% OF COLLECTOR
PEAK VOLTS
        64.3

Pulse Test: Pulse Width = 250us,   Duty Cycle < 0.5%
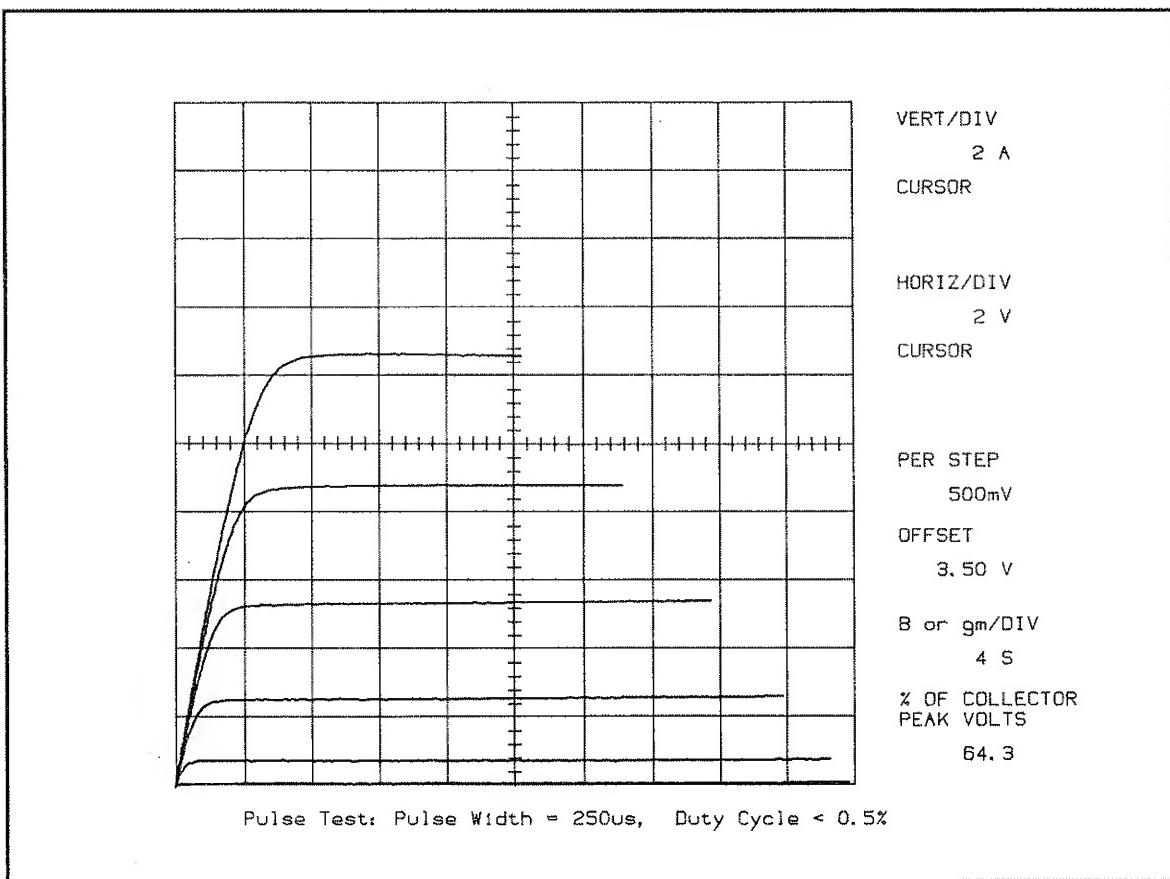
Figure 3-16. Drain current versus drain/source voltage characteristics for a power
              MOSFET.
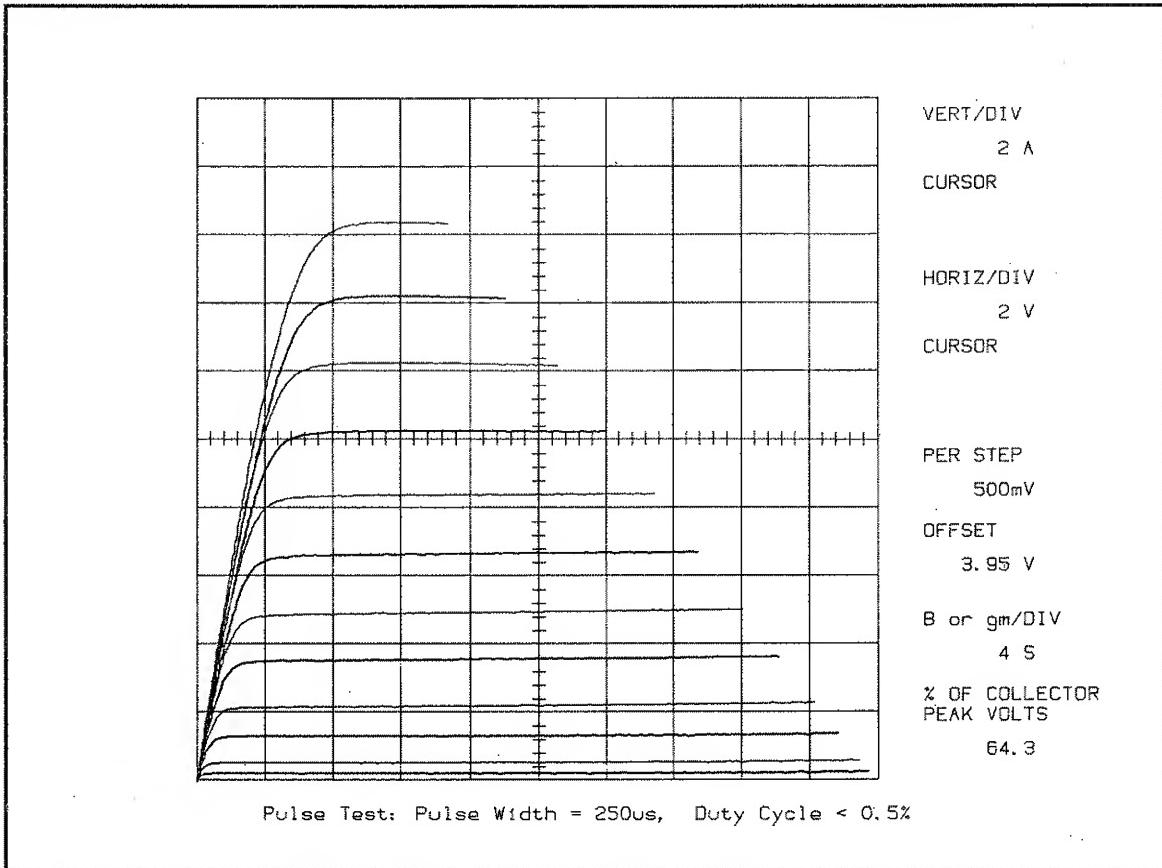
Figure 3-17. Drain current versus drain/source voltage characteristics for 10 steps with the reference display.

Measuring Forward Admittance of a Power MOSFET

This procedure demonstrates how to measure forward admittance of a power MOSFET using the f line cursor.

1. Install an N-channel enhancement-type power MOSFET as described in Steps 2 through 5 of the preceding exercise "Displaying Drain Current versus Drain/Source Voltage Characteristics."

2. Set the memory location to 1, then press the setup RECALL button to initialize the 371A. If you have not saved the initial setup in memory, refer back to "Saving the Initial (Default) Setup" earlier in this chapter.

3. Set other 371A controls as follows:

   A. Collector supply peak power watts to 3 KW or 300 W depending on the MOSFET power rating

   B. Step generator
      SOURCE to VOLTAGE
      NUMBER OF STEPS to 0
      STEP/OFFSET AMPLITUDE to 2 V

   C. VERTICAL CURRENT/DIV to about 1/10 of the rated drain (pulse current)

4. Set the collector supply HIGH CURRENT breaker to the ENABLED position.

5. Select the dot cursor with the cursor select buttons.

6. Rotate the collector supply VARIABLE knob clockwise to move the displayed dot about five divisions to the right.

7. Set the HORIZONTAL VOLTS/DIV control to the STEP GEN (V_{BE}) 1 V position.

8. Press the OFFSET up button to increase the gate/source voltage until desired vertical deflection is obtained.

9. Press the measurement SWEEP button.

   The offset signal automatically sweeps to trace the drain current versus gate-voltage characteristic curve similar to the curve shown in Figure 3-18.
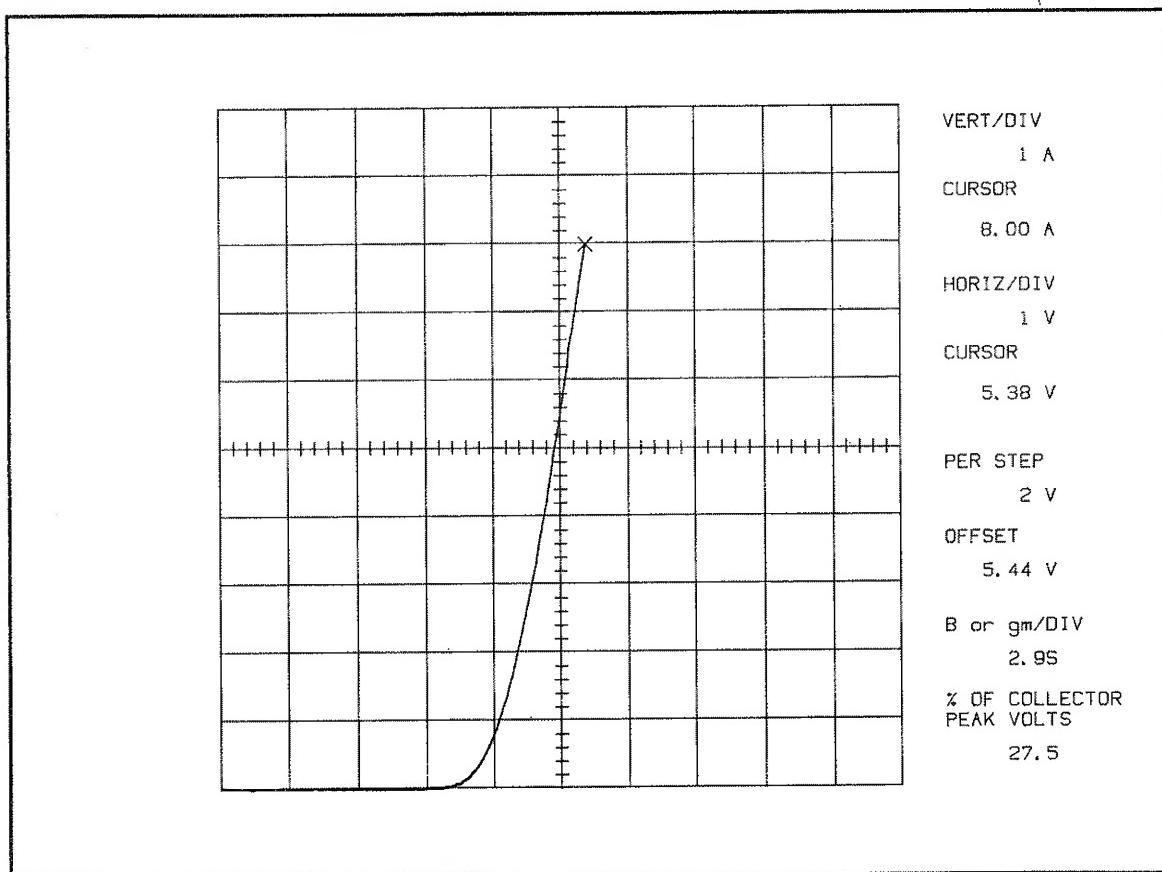
Figure 3-18. Forward transfer curve, I_D = 8 A.

10. Use the cursor position buttons to move the dot cursor until the drain current readout attains the forward transfer admittance measurement condition value.

11. Use the cursor select up button to select the f line cursor.

12. Use the cursor position buttons to adjust the slope of the f line cursor until it is tangent to the curve as shown in Figure 3-19.
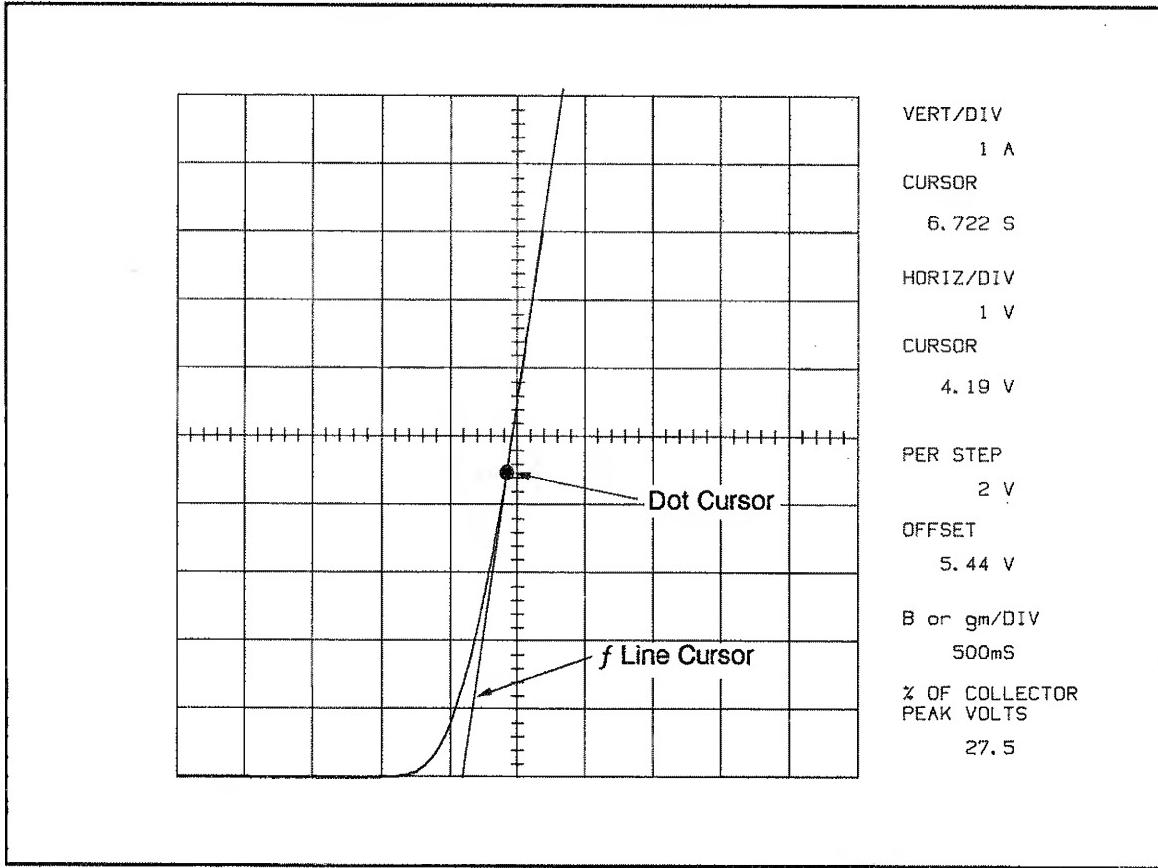
Figure 3-19. Using the *f* line cursor to measure forward transfer admittance of a power MOSFET. In this example, G$_{fs}$ = 6.722 S.

13. The CURSOR (f:1/grad) readout area indicates the forward transfer admittance.

14. Set the collector supply HIGH CURRENT breaker to the DISABLED position.

15. If you are finished testing at this point, open the protective cover, and remove the MOSFET and patch cords. Reinstall the adapter panel if removed.

The 371A is now available for another operation.

Chapter 4
CONTROLS, INDICATORS, AND CONNECTORS

To use the 371A features efficiently you need a clear understanding of the functions and meanings of its controls, indicators, connectors, and readout display areas.

This chapter contains a detailed description of the following:

* Describes the function of all controls, indicators, and connectors on the front panel, rear panel, and test fixture unit of the 371A.

* Provides illustrations to help locate front panel, rear panel, and test fixture unit items.

* Describes the display areas on the 371A CRT.

The controls, indicators, and connectors for the 371A are located on the front and rear panels. The connectors for the device under test (DUT) are located on the patch panel and the adapter panel of the test fixture unit. Setup status and measurement results are indicated in readout areas on the CRT display.

The controls, indicators, connectors, and readout displays are shown and identified in Figures 4-1 through 4-11. The location on the 371A of a specific set of controls is indicated by a black overlay on the control illustration. The descriptions in this section are preceded by index numbers that match the numbers on the illustrations. Control descriptions are presented in numerical order.

Use this section as a reference when you want to know the exact operation and function(s) of a switch, indicator, connector, or readout display area. Refer to Chapter 2: General Operation for a general explanation of how the 371A operates. Refer to Chapter 3: Exercises for specific demonstrations of the controls as they are actually used to perform semiconductor device measurements.

INSTRUMENT POWER AND CRT CONTROLS

Figure 4-1 shows the location of these controls on the front-panel.
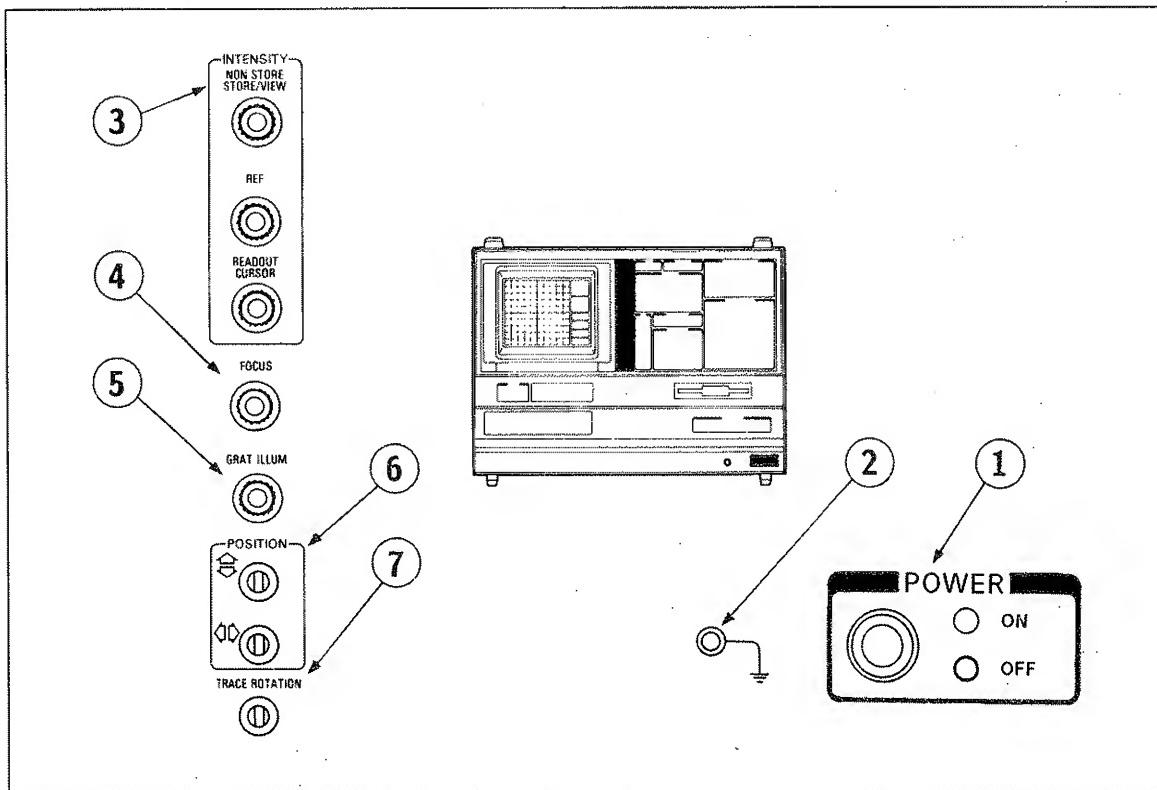
Figure 4-1. Instrument Power and Display controls.

(1)   POWER

The POWER switch connects the 371A to its power source. Press the switch to connect the 371A to its power source; press the switch again to disconnect the 371A from its power source.

(2)   GROUND CONNECTOR

The front-panel ground connector, located beside the POWER switch, is used to connect the 371A to an external ground level, wrist strap, and any other item that may require grounding.

(3)   **INTENSITY**

There are three intensity controls:

NON STORE/STORE/VIEW
  The NON STORE/STORE/VIEW intensity knob controls the waveform display
  intensity in the non store, store, or view modes, respectively.

REF (Reference)
  The REF intensity knob controls the intensity of the reference waveform display.

READOUT/CURSOR
  The READOUT/CURSOR intensity knob controls the intensity of the readout text,
  the f line cursor, and the window cursor.

(4)   **FOCUS**

The FOCUS knob controls the focus of the CRT display.

(5)   **GRAT ILLUM (Graticule Illumination)**

The GRAT ILLUM knob controls the illumination level (brightness) of the CRT
graticule.

(6)   **POSITION**

The POSITION screwdriver adjustments control the vertical and horizontal position of
display information.

(7)   **TRACE ROTATION**

The TRACE ROTATION screwdriver adjustment adjusts the slant of the display
information in reference to the graticule.

SETUP, MEMORY INDEX, AND MEASUREMENT CONTROLS

Control locations are shown in Figure 4-2.
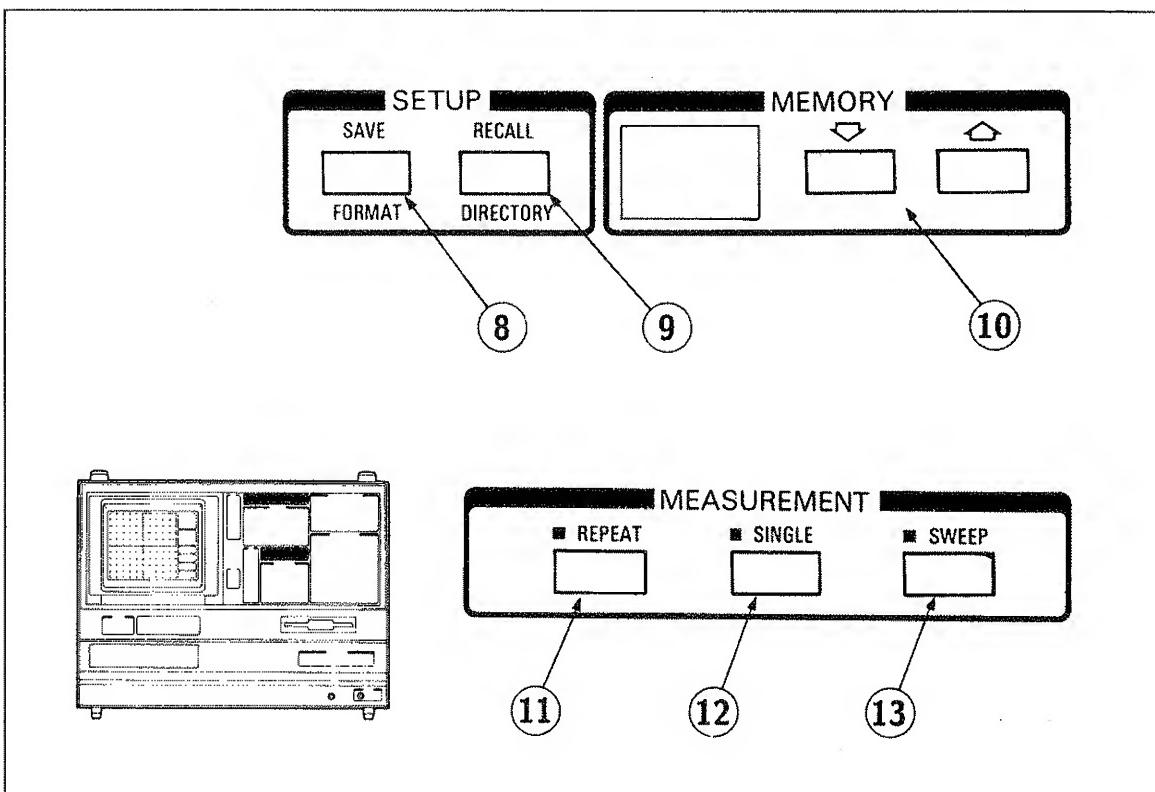
Figure 4-2. Setup, Memory Index, and Measurement controls.

(8)   SAVE/FORMAT

This button has two functions:

- Press the SAVE button to save the front-panel setup in memory at the user-selected memory index location.

- Hold down the cursor SHIFT button and then pressing the SAVE button, to initiate formatting a floppy disk.

(9) RECALL/DIRECTORY

This button has two functions:

- Press the RECALL button to recall a previously-stored group of 371A front-panel settings (setups). The 371A controls are then set to the front-panel settings read from the selected memory index location.

- Hold down the cursor SHIFT button and press the RECALL button to display the first page of a directory of the contents of mass storage (contents of both non-volatile memory and floppy disk). Use the memory up and down buttons to "page" through the directory.

(10) Memory Location Display (LED readout)

This two-digit LED display has two functions:

- It indicates the memory location to or from which front-panel setups and characteristic curves will be stored or read, respectively. Such indications occur when performing enter, save, recall, or view functions.

- When in directory display mode, it indicates the number of the directory page currently being displayed.

You move up or down through memory locations and directory pages using the memory up and down buttons. When you hold down the cursor SHIFT button while pressing the memory up or down button, the rate of change increases.

Simultaneously pressing the memory up and down buttons sets the memory location (or directory page) number to 1.

(11) REPEAT/Copy from RAM to Disk

This button has two functions:

- Press the REPEAT button to cause the 371A to generate repetitive base and collector pulses. In this way the measurement is performed repeatedly.

- When you hold down the cursor SHIFT button and press the REPEAT button, the function of this button changes to COPY from non-volatile memory to disk. (Note that this function name is not silkscreened below the button.) The copy function can be used to simultaneously copy up to 16 characteristic curves and 16 front-panel setups from non-volatile memory to floppy disk. For additional information, refer to "Copying from Non-Volatile Memory to Floppy Disk" in Chapter 2: General Operation.

(12) SINGLE/Copy from Disk to RAM

This button has two functions:

- Each time you press the SINGLE button, the step generator generates one set of step signals and the measurement is performed once. In high-voltage mode, the collector supply provides continuous output, but when in high-current mode it provides one set of pulses, depending on the number of steps selected for the step generator.

- When you hold down the cursor SHIFT button and then press the SINGLE button, the function of this button changes to COPY from disk to non-volatile memory. (Note that this function name is not silkscreened below the button.) The copy function can be used to simultaneously copy up to 16 characteristic curves and 16 front-panel setups from floppy disk to non-volatile memory. For additional information, refer to "Copying from Floppy Disk to Non-Volatile Memory" in Chapter 2: General Operation.

(13) SWEEP

When you press the SWEEP button, the collector supply (or step generator) output automatically sweeps from zero (or 0 A/V) to the value set by the collector supply VARIABLE control (or step generator amplitude + offset).

Sweep mode is available when the collector supply is in high-current mode and when store mode is selected.

When sweeping in the collector supply mode, the measurement is performed as step signals are generated repeatedly over the sweep range.

When sweeping in the step generator mode, the output is limited to 10 times the STEP AMPLITUDE setting; except for the 5 V or 2 A settings. In this exception, the output is limited to five times the STEP AMPLITUDE setting. When the sweep is complete, the output of the step generator returns to the starting offset value. The number of steps remains at 0.

DISPLAY CONTROLS

Display controls shown in Figure 4-3 are used to select display modes and to control the vertical and horizontal sensitivity of the characteristic curve display area.
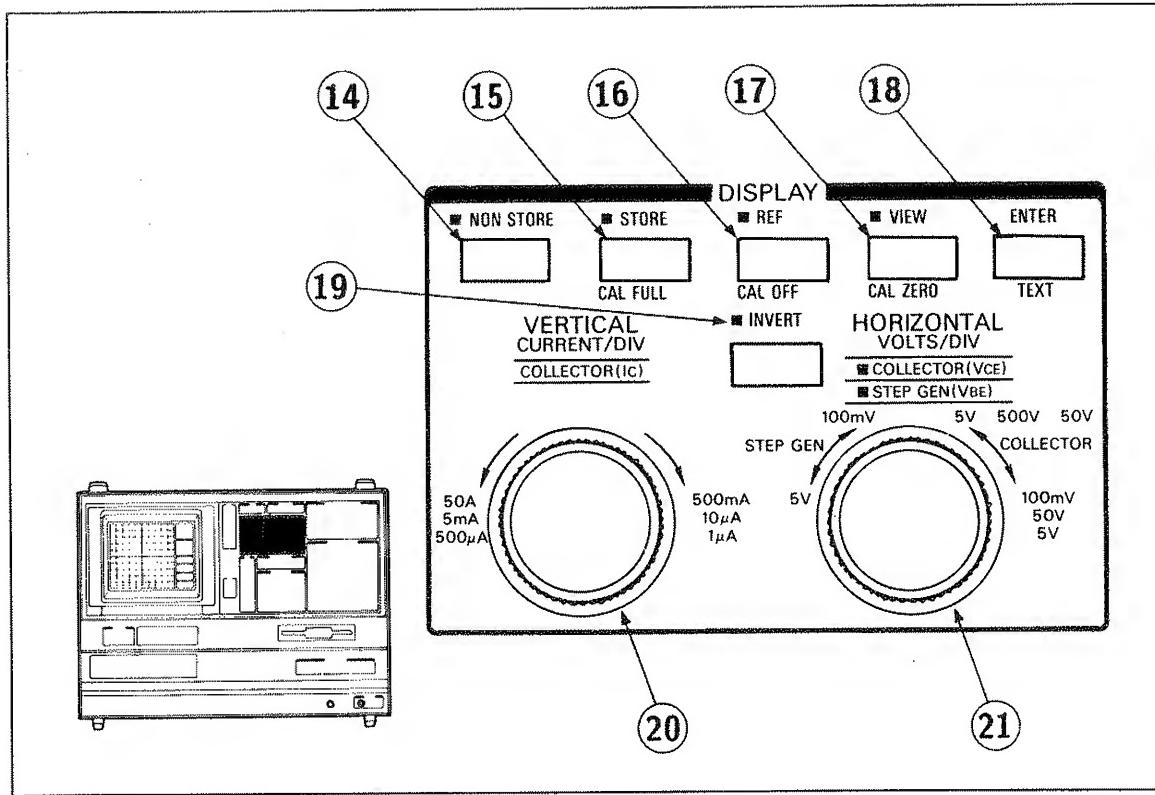
Figure 4-3. Display controls.

(14)   NON STORE

Press the NON STORE button to provide a real-time analog display of the device characteristic curve.

(15)   STORE/CAL FULL

This button has two functions:

* Press the STORE button to display a digitized characteristic curve of the DUT. The characteristic curve is calculated, digitized, and then converted to analog signals for display on the CRT.

- Hold down the cursor SHIFT button and press the STORE button to change the function to CAL FULL (calibration full) which displays a dot in the top right corner of the screen. This function provides a reference for checking the CRT deflection at the 10th graticule lines (vertical and horizontal).

  While in the calibration mode, CAL is displayed in the top right corner of the display.

(16) REF/CAL OFF (Reference/Calibration Off)

This button has two functions:

- Press the REF button to save the currently displayed store or view curve in the reference waveform memory and to display the entered curve as a reference curve. Either the store or view curve can be displayed together with the reference curve. The reference curve remains on the CRT until either the REF button is pressed again or non store display mode is selected.

  If you press the SAVE button when the reference curve is displayed, the reference curve is saved along with front-panel settings in the selected setup memory location.

- Hold down the cursor SHIFT button and press the CAL OFF button to cancel the calibration full or calibration zero function.

(17) VIEW/CAL ZERO

This button has two functions:

- Press the VIEW button to read a characteristic curve from a selected memory location and to display the curve on the CRT. The memory location number is briefly displayed in the bottom right of the CRT.

NOTE

If any control setting (except REF) is changed while in view mode, the display mode automatically changes to store mode in order to reflect the results of the changed setting.

- Hold down the cursor SHIFT button and press the VIEW button to change the function to CAL ZERO, which displays a dot in the bottom left corner of the screen. This function provides a reference for checking the CRT deflection at the "zero point" of the vertical and horizontal graticule lines.

  While in the calibration mode, CAL is displayed in the top right corner of the display.

(18) ENTER/TEXT

This button has two functions:

* Press the ENTER button to store the currently displayed store or view curves in mass storage at the selected memory location. (The enter function is not used with the non store display mode.)

* Hold down the cursor SHIFT button and press the ENTER button to activate text edit mode. Text edit mode enables you to enter up to 24 alphanumeric characters and symbols to help identify or label characteristic curves and setup displays.

    Press the ENTER button to exit text entry mode.

    Refer to "Text Edit Mode" in Chapter 2: General Operation for additional details on using this lode. Also, refer tn "First-Time Operating Exercises" in Chapter 3: Exercises for an exercise that demonstrates text entry.

(19) INVERT

This button has two functions:

* Press the INVERT button to invert the non store or store curve on the horizontal and vertical axes. The INVERT LED illuminates. The invert function does not affect either the view or reference curves.

* Hold down the cursor SHIFT button and press the INVERT button to activate the "erase non-volatile memory contents" feature. Note that this secondary function is not printed below the button. Refer to "Erasing Non-Volatile Memory" in Chapter 2: General Operation for additional information.

(20) VERTICAL CURRENT/DIV

This control sets the sensitivity of the vertical axis. The sensitivity per division of the vertical axis is displayed in the VERT/DIV readout area on the display screen. The sensitivity selection range depends on the collector supply peak power watts setting as listed in Table 4-1.

Table 4-1
Vertical Axis Sensitivity Settings

Peak Power Watts	CURRENT/DIV Range
3 kW	1 A/div to 50 A/div
300 W	500 mA/div to 5 A/div
30 W	100 μA/div to 5 mA/div
3 W	10 μA/div to 500 μA/div
300 mW	10 μA/div to 500 μA/div
300 mW	1 μA/div to 50 μA/div

Table 4-2 shows the VERT/DIV (vertical per division) selections controlled by the VERTICAL CURRENT/DIV (vertical current per division) control, for specific collector supply settings.

(21) HORIZONTAL VOLTS/DIV

This is a dual purpose control. It selects the source (collector or step generator) and adjusts the sensitivity (volts/division) for the horizontal axis. The sensitivity of the horizontal axis is displayed in the HORIZ/DIV (horizontal per division) readout area on the display screen.

Table 4-2 shows selections controlled by the HORIZONTAL VOLTS/DIV control for specific collector supply settings.

To select the collector supply as the source, rotate the knob clockwise until the COLLECTOR (V_{CE}) indicator located above the control lights. You can then position the control accordingly to select collector (V_{CE}) settings as listed in Table 4-2.

To select the step generator as the source, rotate the HORIZONTAL VOLTS/DIV control counterclockwise until the STEP GEN (V_{BE}) indicator located above the control lights. You can then position the control accordingly to select the step generator (V_{BE}) settings as listed in Table 4-2.

Table 4-2
Display Sensitivity Selections

| Collector Supply | | | | VERTICAL | HORIZ VOLTS/DIV | |
| High Current | | High Voltage | | CURRENT/DIV | Selections | |
3 kW	300 w	30 W	3 W	Selections	STEPGEN (V_{BE})	COLLECTOR (V_{CE})
X				50 A 20 A 10 A 5 A 2A 1 A	5 V 2 V 1 V 500 mV 200 mV 100 mV	5 V 2 V 1 V 500 mV 200 mV 100 mV
	X			5 A 2 A 2 A 500 MA	5 V 2 V 1 V 500 mV 200 mV 100 mV	5 V 2 V 1 V 500 mV 200 mV 100 mV
		X		5 mA 2 mA 1 mA 500 µA 200 µA 100 µA	5 V 2 V 1 V 500 mV 200 mV 100 mV	500 V 200 V 100 V 50V
			X	500 µA 200 µA 100 µA 50 µA 20 µA 10 µA	5 V 2 V 1 V 500 mV 200 mV 100 mV	500 V 200 V 100 V 50V

CURSOR CONTROLS

The cursor controls, shown in Figure 4-4, are used to select and position the dot, f line, and window cursors.
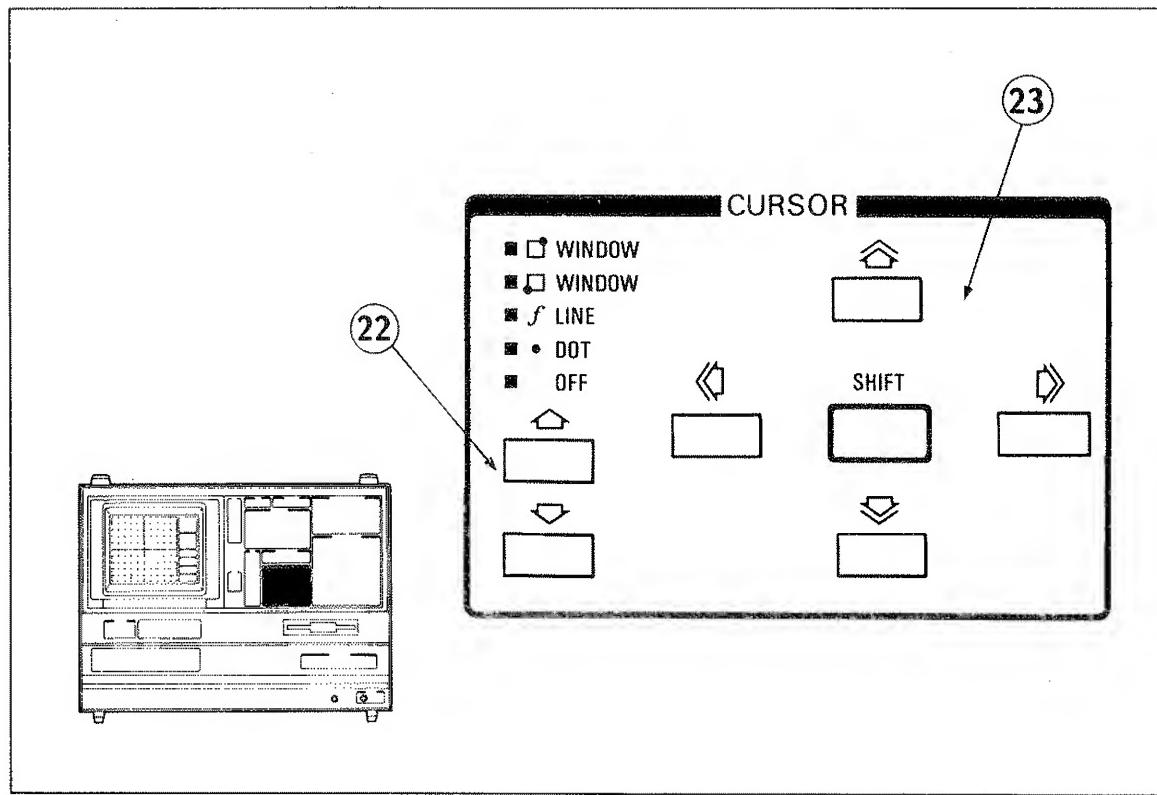
Figure 4-4. Cursor controls.

(22)   Cursor Selection Buttons

The cursor select up or down buttons are used to select the dot, f line, or window cursors.

* The dot cursor is a high-intensity dot displayed on the characteristic curve trace. Voltage and current at the cursor position are indicated in the CURSOR readout area. This cursor is also used to measure ß (beta)

The dot cursor is positioned using the four cursor position buttons. If the dot cursor is positioned off screen, the corresponding part (vertical or horizontal) of the CURSOR readout blinks.

When a reference curve is displayed, the dot cursor is displayed only on the store or view curve. The dot cursor is not displayed in the non store display mode.

- The f line (function line) cursor is used to measure either the "on" resistance or the horizontal intercept voltage of a DUT. The f line cursor is a straight line that passes through the dot cursor position at a slope that can be changed by the four cursor position buttons. The slope is indicated in the CURSOR (f:1/grad) readout area of the CRT.

  The point at which the f line cursor intercepts the horizontal axis is indicated in the CURSOR (f: 1/intercept) readout area, which indicates the horizontal coordinate value.

  If the reference curve is displayed, the f line cursor appears only on the store or view curve. The f line cursor is not displayed in non store mode

- A rectangular window cursor can be used in any display mode as a reference for visual checks. It can also be used to measure small signal ß (beta).

  You can select one of two window cursors; one with a bright dot in its bottom left corner, the other with a bright dot in its top right corner. Cursor movement and the cursor readout display are referenced to the bright dot.

Refer to "Using Display Cursors" in Chapter 2: General Operation for additional information. Also, refer to "Measurement Exercises" in Section 3: Exercises for exercises that demonstrate the use of the dot, f line, and window cursors.

(23) Cursor Position Buttons and SHIFT Button

The four cursor position buttons (up down left right) are used to either move the dot and window cursors, or to change the slope of the f line cursor. Holding down the cursor SHIFT button and pressing any of the cursor position buttons makes the cursor move faster.

The cursor SHIFT button is also used to change the function of other controls on the front panel. The alternate function is printed in blue below each button. Table 4-3 shows the alternate functions that can be selected by the cursor SHIFT button.

Table 4-3
Alternate Functions Controlled by the SHIFT Button

Button	Alternate Effect
SAVE	Changes the button function to FORMAT, to initiate floppy disk formatting.
RECALL	Changes the button function to DIRECTORY, which displays a directory of the contents of the mass storage on the CRT.
STORE	Changes the button function to CAL FULL, which displays a dot to check the deflection accuracy of the CRT.
REF	Changes the button function to CAL OFF, which turns off the cal full or cal zero display.
VIEW	Changes the button function to CAL ZERO, which displays a dot to check the deflection accuracy of the CRT.
ENTER	Changes the button function to TEXT, which places the 371A in text edit mode for text entry and revision.
REPEAT	Changes the button function to COPY, which copies the contents of non-volatile memory to floppy disk. *This alternate function is not printed below the button.*
SINGLE	Changes the button function to COPY, which copies the contents of the floppy disk to RAM. *This alternate function is not printed below the button.*
Cursor Position (up, down, left, right)	Increase the rate of cursor movement.
RESET to LOCAL	Changes the button function to ADDR, which reads in the settings of the rear-panel configuration switch bank and displays them on the CRT.
USER REQUEST	Changes the button function to ID, which displays the firmware version of the 371A on the CRT.
PLOT	Changes the button function to CURVE, which plots only the curve (without the graticule, cursor, text, and readout).
OFFSET (up down)	Increases the rate of offset increase or decrease.
STEP MULTI	Changes the button function to DISABLE, which disables the step generator output.

STEP GENERATOR CONTROLS

The step generator controls are shown in Figure 4-5.
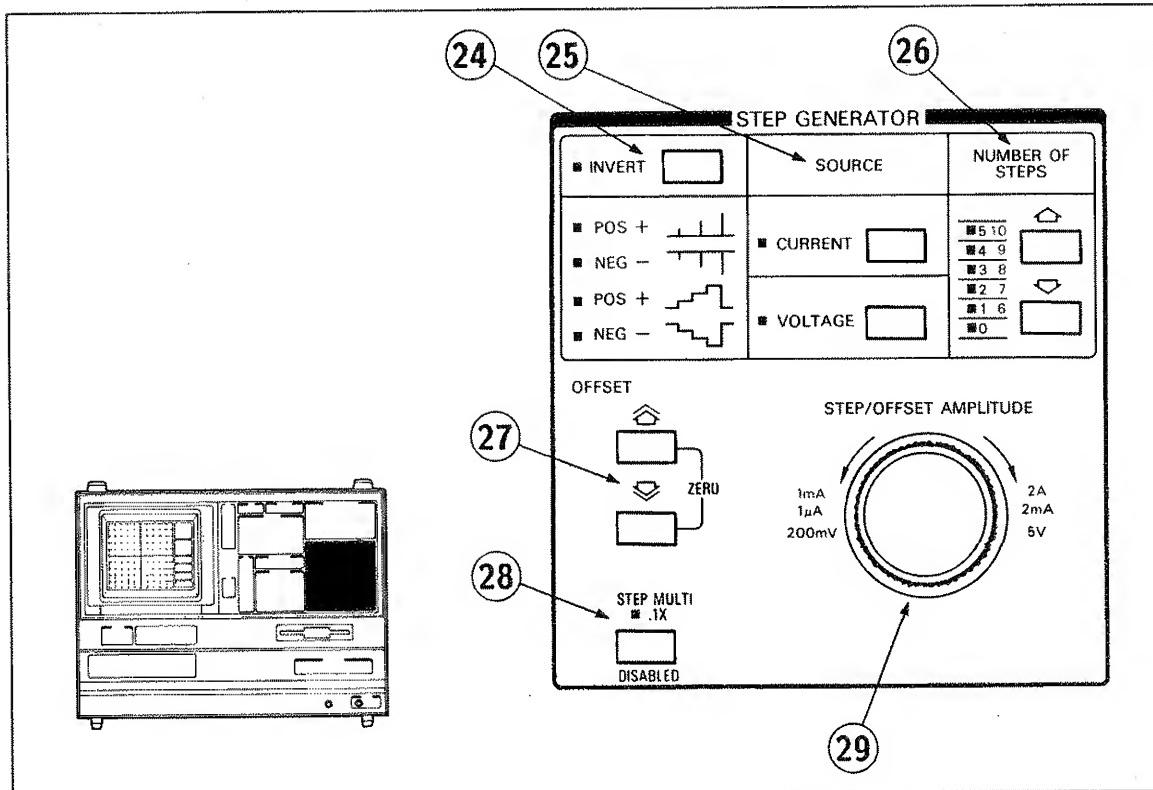
Figure 4-5. Step Generator controls.

(24) INVERT

Press the polarity INVERT button to invert the polarity of the step generator. The step generator polarity is automatically changed when the collector supply polarity is changed. Therefore, when necessary, the INVERT button is used to reverse polarity changes caused by changing the collector supply polarity.

The INVERT indicator, located beside the button is lit to indicate inverted polarity.

(25) SOURCE

Press either the CURRENT button or VOLTAGE button to set the step generator output to either a current step signal or a voltage step signal. The selected source is indicated by the corresponding LED.

(26) NUMBER OF STEPS

Use the NUMBER OF STEPS up or down buttons to select the number of steps produced by the step generator.

The range of steps is selectable from 0 to 10 except when the step amplitude is set to either 5 V or 2 A. In the latter case, the maximum offset is limited to five times the step amplitude. If the offset is over five times and the step amplitude is changed to either 5 V or 2 A, the offset will be changed automatically to the maximum allowable in those settings, five times.

NOTE

When 0 steps are selected, the step generator output consists of offset only. Refer to the description of the OFFSET button immediately following for additional information.

Simultaneously press the up and down buttons to set the number of steps to 2. The NUMBER of STEPS LEDs are green for steps 0 to 5; orange for steps 6 to 10.

(27) OFFSET

The up and down OFFSET buttons allow you to add an offset level to the step signal. The offset has the same polarity as the step signal.

The range of step offset is from 0 to 10 times the step amplitude for most step amplitude settings. When the step amplitude is set to either 5 V or 2 A, the maximum offset is reduced to five times the step amplitude. If the offset is over five times and the step amplitude is changed to either 5 V or 2 A, the offset will be changed automatically to the maximum allowable in those settings, five times.

When the step signal is a pulse signal, the offset level is added as a pulse. The selected amount of offset is displayed in the OFFSET readout area of the CRT.

Hold down the cursor SHIFT button and press either of the OFFSET buttons to cause offset changes in larger increments.

Simultaneously press the OFFSET up and down buttons to set the offset to zero.

(28) STEP MULTI .1X/DISABLED

This is a dual function button that provides the following functions.

- Press the STEP MULT .1X button to reduce the step signal amplitude by a factor of 10 without affecting the offset amplitude. The indicator above the button lights when the step multi function is enabled.

- Hold down the cursor SHIFT button and press the STEP MULTI .1X button to change the button function to DISABLED. This action disables the output and readout display functions of the step generator.

(29) STEP/OFFSET AMPLITUDE

Rotate the STEP/OFFSET control to set the amplitude of the generated steps and the range of the offset.

The step amplitude is selected in a sequence of steps in the following ranges:

Current steps:

When the collector supply is in high-voltage mode	Step waveform, 1 µA/step to 2 mA/Step
When the collector supply is in high-current mode	Pulse waveform, 1 mA/step to 2 A/step
Voltage Steps:	Step waveform 200 mV/step to 5 V/step

Offset amplitude is set by using the STEP/OFFSET AMPLITUDE control together with the OFFSET buttons.

COLLECTOR SUPPLY CONTROLS

The collector supply controls are shown in Figure 4-6.
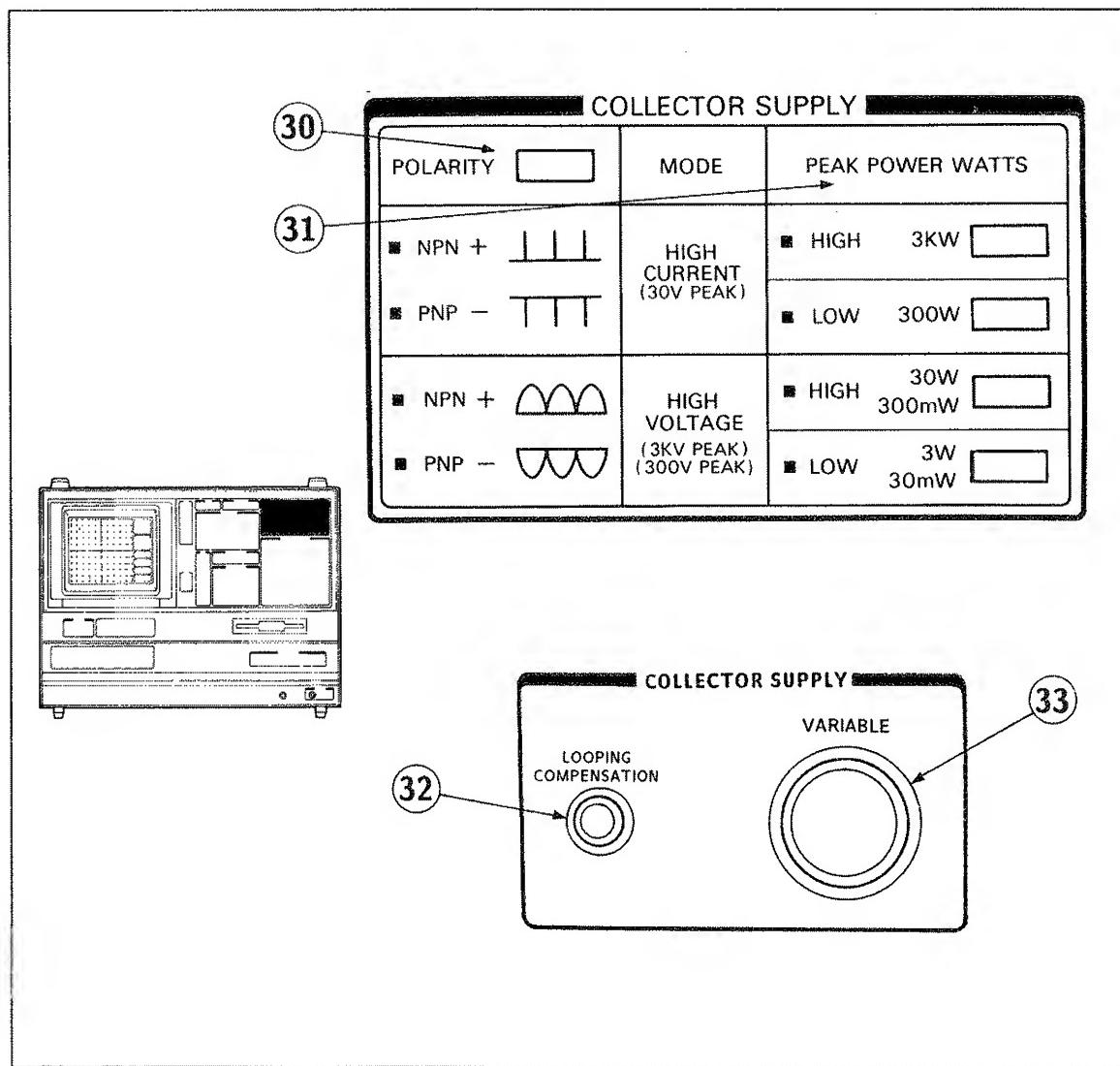
Figure 4-6. Collector Supply controls.

(30) Polarity

Press this button to select the polarity of the collector supply and to simultaneously switch the polarity of the step generator.

Each polarity setting (NPN+ and PNP- for high voltage and NPN+ and PNP- for high current) has an indicator which is lighted when that setting is selected.

The collector supply output automatically goes to 0% when the polarity is switched. The step generator output level remains unchanged (except for the reversed polarity).

(31) PEAK POWER WATTS

The peak power watts buttons select the maximum power output of the collector supply. The six peak power watt selections, 30 mW, 300 mW, 3 W, 30 W, 300 W, and 3 kW, are split between two collector supply modes: high current and high voltage.

To select the 30 mW or 300 W range, hold down the cursor SHIFT button and then press the 3 W or 30 W peak power watts button. The red LED lights if the 30 W or 3 W setting is selected, and the green LED lights if the 3 kW, 300 W, 300 mW, or 30 mW setting is selected.

Press the 3 kW or 300 W button to place the collector supply in high-current mode, where the output consists of 250 μs pulses and the peak voltage available is 30 V.

Press either the 30 W or 3 W button to place the collector supply in high-voltage mode, where the output is a full-wave rectified sine wave and the maximum voltage available is 3 kV. When either 30 W or 3 W is selected, the PEAK POWER WATTS LED lights green.

The collector supply output automatically goes to 0% when the maximum voltage setting is changed.

(32) LOOPING COMPENSATION

Use the LOOPING COMPENSATION control to compensate for stray capacitance that may occur in the 371A and test fixture unit when the collector supply is in high-voltage mode.

(33) VARIABLE

Rotate the collector supply VARIABLE knob to vary the collector supply voltage output. The output voltage is indicated in the % of COLLECTOR PEAK VOLTS readout area as a percent of the peak voltage available.

GPIB CONTROLS AND FLOPPY DISK DRIVE

The GPIB controls and floppy disk drive are shown in Figure 4-7.
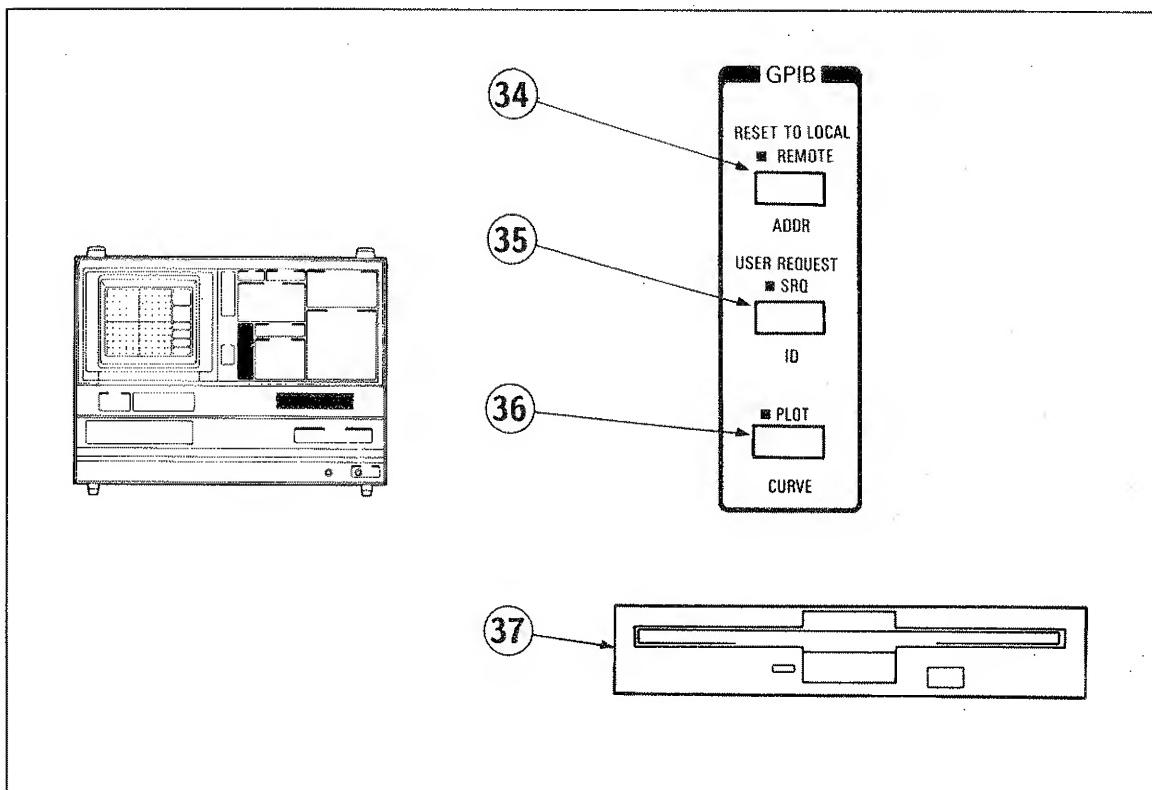
Figure 4-7. GPIB controls and Floppy Disk Drive.

(34) RESET TO LOCAL/ADDR and the REMOTE Indicator

The RESET TO LOCAL/ADDR button has two functions:

- When the 371A is controlled by the GPIB, the REMOTE indicator lights. Press the RESET TO LOCAL button to switch the 371A back to local (front panel) control.

  When the remote enable (REN) signal has been sent over the GPIB and my listen address (MLA) is received, the 371A goes into remote mode and the REMOTE indicator is lit. In remote mode, the 371A executes interface messages and device-dependent messages received via the GPIB.

- Hold down the cursor SHIFT button and press the RESET TO LOCAL button to change the button function to ADDR. This causes the 371A to read the GPIB address and message terminator selections on the rear-panel TERMINATION and ADDRESS SELECT switches. Once received by the 371A internal processor, the selections are displayed on the CRT.

(35) USER REQUEST/ID and the SRQ Indicator

This button has two functions:

* Press the USER REQUEST button to make the 371A send a service request (SRQ) signal over the GPIB.

  The SRQ indicator, located above the USER REQUEST button, lights to indicate that a service request is being sent. The SRQ indicator goes off when a serial poll is executed and the controller acknowledges the service request.

* Hold down the cursor SHIFT button and press the USER REQUEST button to change the button function to ID. This action displays the 371A firmware version number on the display screen.

(36) PLOT/CURVE

This button has two functions:

* Press the PLOT button in store or view mode to send the displayed curve, cursor, text, graticule, and setup information to a plotter connected to the PLOTTER INTERFACE PORT on the rear panel.

  The PLOT indicator lights while data is transferred. When data transfer is completed, the indicator goes off and the 371A sends a service request (SRQ) signal on the GPIB.

  Messages and the memory location number displayed in view mode are not sent to the plotter.

  To halt output to the plotter, press the PLOT button.

* Hold down the cursor SHIFT button and press the PLOT button to change the button function to CURVE. This action sends only the curve (without text, cursor, graticule, and setup information) to the plotter.

(37) Floppy Disk Drive

A 3.5 inch floppy disk drive unit provides data storage capability. Up to 64 displays can be stored or recalled using the ENTER or VIEW buttons, respectively. Up to 64 front-panel setups can be stored or recalled by pressing the SAVE or RECALL buttons, respectively.

When lit, the LED indicator indicates that the disk drive is active, and that the drive is either reading from or writing to the disk. When the LED is off, the drive is inactive.

Press the eject button to remove the disk.

> ┌─────────────────┐
> │   CAUTION   │
> └─────────────────┘

Do not press the eject button while the LED indicator is on. The disk drive or the floppy disk can be damaged.

SIGNAL OUTPUT CONTROLS, INDICATORS, AND CONNECTORS

Signal output controls, indicators, and connectors are shown in Figure 4-8.
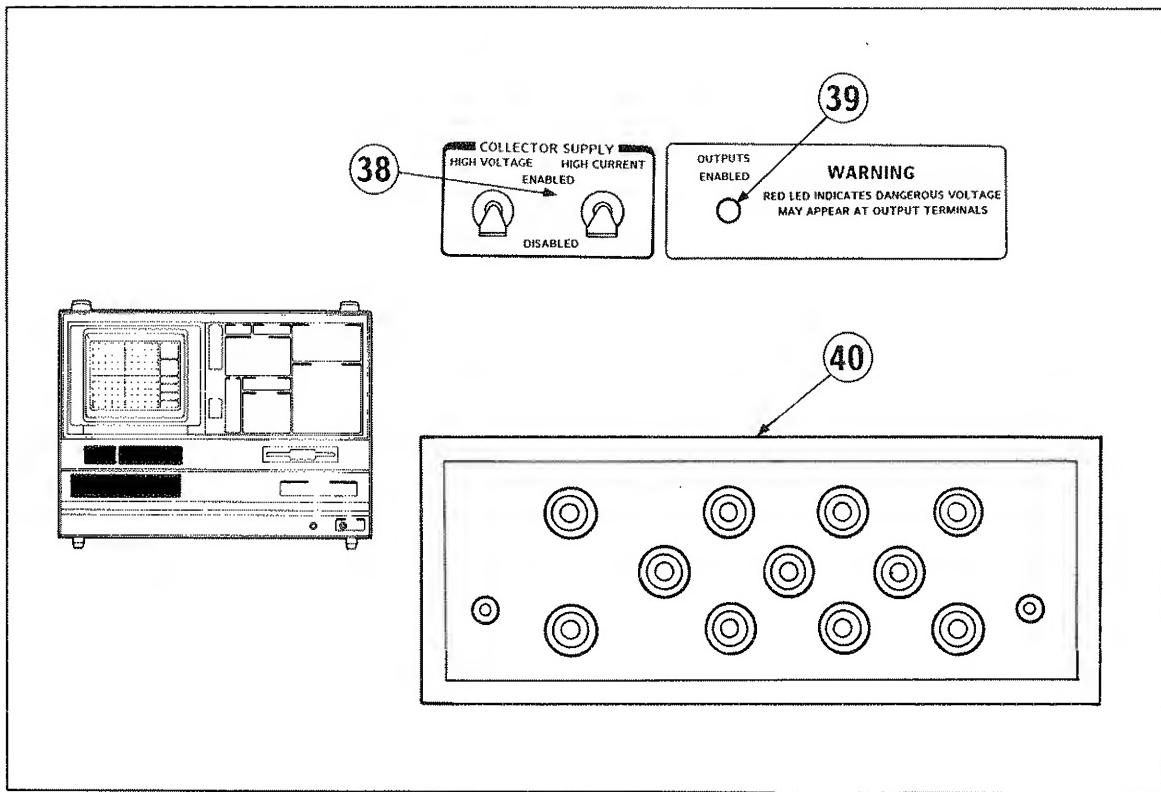
Figure 4-8. Signal output controls, indicators, and connectors.

(38) COLLECTOR SUPPLY Circuit breakers

The HIGH VOLTAGE and HIGH CURRENT circuit breakers enable or disable the collector supply output. If the 371A detects an overcurrent condition, it automatically trips the breakers to disable output.

(39) OUTPUTS ENABLED Indicator

The OUTPUTS ENABLED indicator lights when the collector supply or step generator outputs are enabled.

This indicator turns off when one of the following occurs:

- the test fixture unit is not connected
- the test fixture unit protective cover is open
- the collector supply peak power is exceeded
- the output is disabled for any other reason

When the OUTPUTS ENABLED indicator is off, both the output and sense connectors are open circuits.

(40) Text Fixture Connector

The test fixture connector provides interconnection between the test fixture unit and the 371A.

REAR PANEL

The rear panel is shown in Figure 4-9
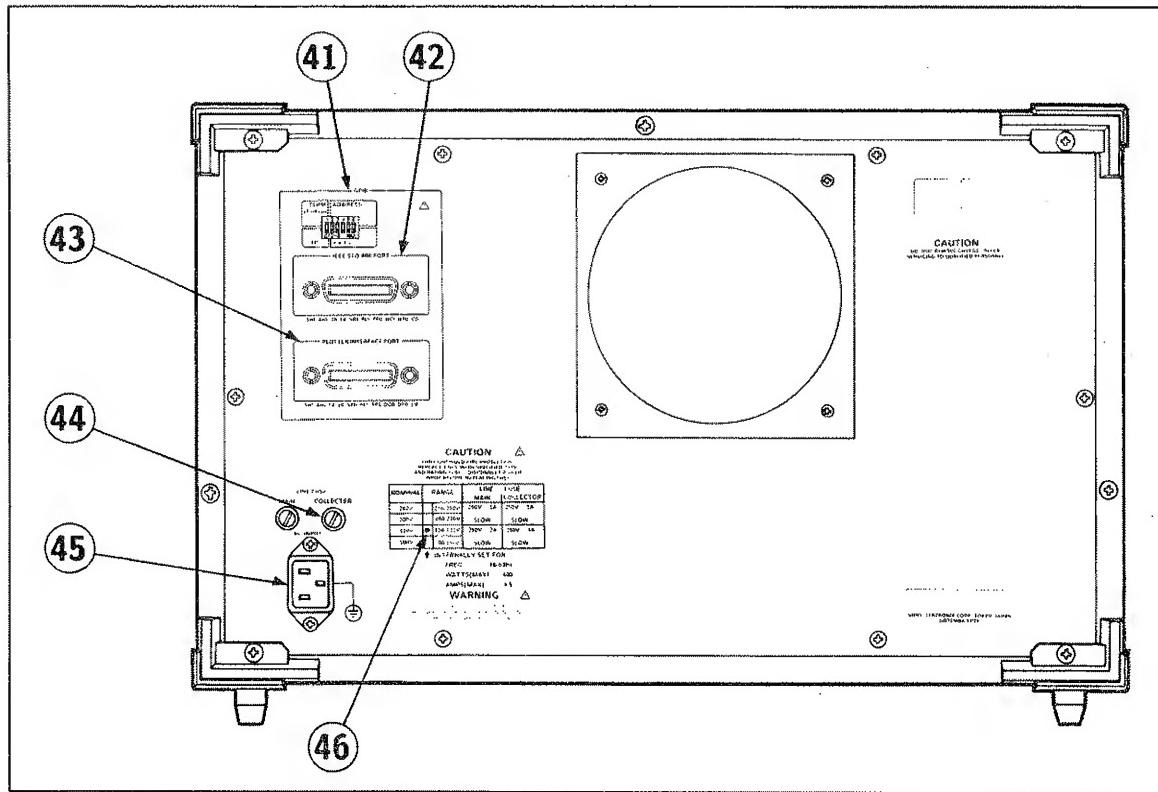
Figure 4-9. Rear-panel controls and connectors.

(41) GPIB TERMINATOR and ADDRESS Switch

The GPIB TERM (termination) switch and the ADDRESS switch selects the message terminator and sets the 371A GPIB address. Refer to "Choosing the Message Terminator" in Chapter 5: GPIB for additional information.

The left-most switch (as viewed when facing the rear panel) sets the message terminator; the other five switches set the address of the 371A on the GPIB. New settings become effective when the RESET TO LOCAL/ADDR button (on the front panel) is pressed while holding down the cursor SHIFT button. Refer to "Configuration Switch Settings" and "Setting the Bus Address" in Chapter 5:GPIB for additional information.

(42) IEEE STD 488 PORT

This is the GPIB connector.

(43) PLOTTER INTERFACE PORT

This is the plotter interface port. No external controller is needed.

(44) LINE FUSE

The MAIN fuse receptacle contains the power line fuse. The COLLECTOR fuse receptacle contains the collector supply fuse.

(45) AC INPUT

This connector is for the AC power cord.

(46) LINE VOLTAGE Setting

The line setting of the 371A is indicated by a screw in this area on the rear panel.

TEST FIXTURE UNIT AND PATCH PANEL CONNECTORS

The following describes the signal lines at the connectors on the patch and adapter panels of the test fixture unit. These connectors are shown in Figure 4-10.
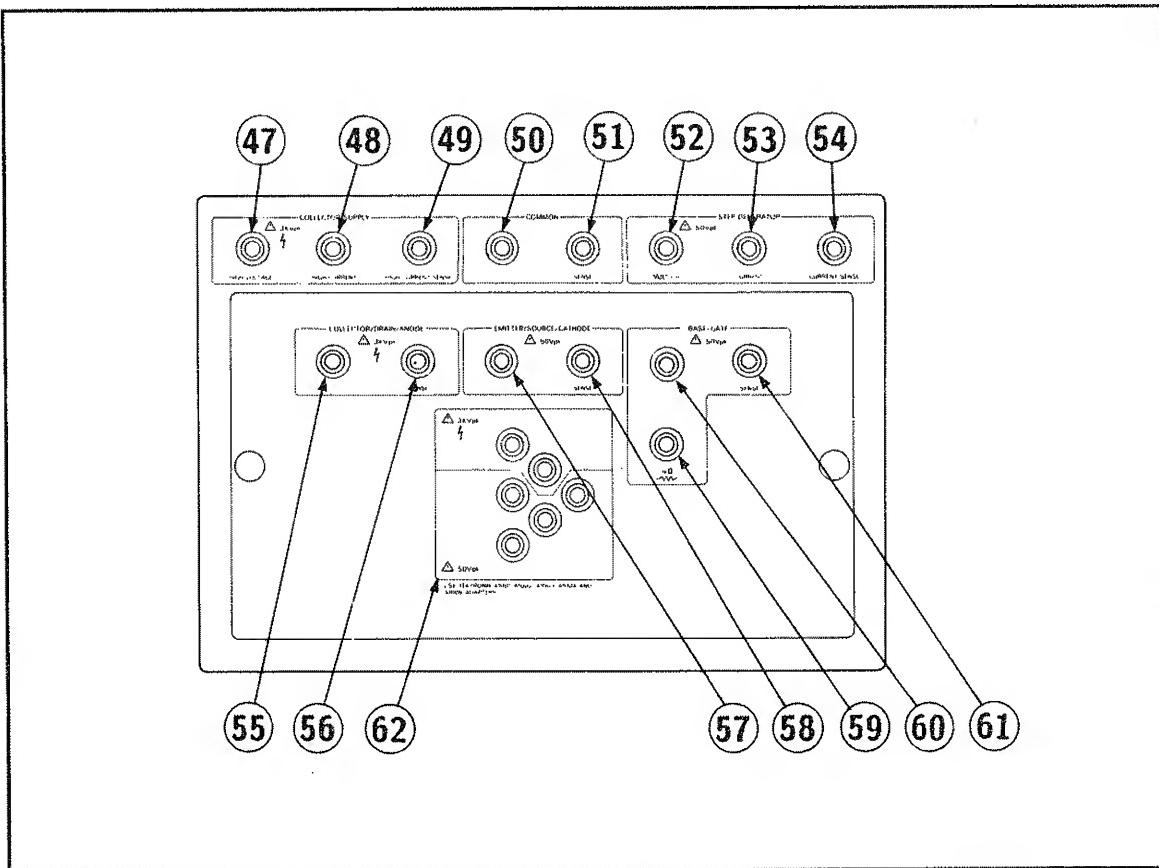
Figure 4-10. Test fixture unit connectors.

(47) COLLECTOR SUPPLY HIGH VOLTAGE

The COLLECTOR SUPPLY HIGH VOLTAGE connector is the collector supply output in high-voltage mode (when the peak power watts setting is 30 mW, 300 mW, 3 W, or 30 W).

A rectified sine wave with a maximum amplitude of 300 V (30 mW or 300 mW) or 3 kV (3 W or 30 W) is available at this connector.

(48) COLLECTOR SUPPLY HIGH CURRENT

The COLLECTOR SUPPLY HIGH CURRENT connector is the collector supply output in high current mode (when the peak power watts setting is 300 W or 3 kW).

A voltage pulse with a maximum amplitude of 30 V and a pulse width of 250 µs is available at this connector.

(49) COLLECTOR SUPPLY HIGH CURRENT SENSE

The COLLECTOR SUPPLY HIGH CURRENT SENSE connector is the collector voltage sense connector in high current mode (when the peak power watts setting is 300 W or 3 kW).

(50) COMMON

The COMMON connector is the signal common for the collector supply and the step generator outputs.

(51) COMMON SENSE

The COMMON SENSE connector is used as the common sense voltage line.

(52) STEP GENERATOR VOLTAGE

The STEP GENERATOR VOLTAGE connector is the output for the step generator signal in voltage source mode.

(53) STEP GENERATOR CURRENT

The STEP GENERATOR CURRENT connector is the output for the step generator signal in current source mode.

The output can be either a pulse with a maximum amplitude of 10 A, offset of 10 A, and a width of 500 µs, or a staircase signal with a maximum amplitude of 20 mA and offset of 20 mA. Which output is available depends on whether you are operating the collector supply in high-voltage or high-current mode.

(54) STEP GENERATOR CURRENT SENSE

The STEP GENERATOR CURRENT SENSE connector is the sense input for base voltage (V_{BE}) measurements in current source mode.

(55) COLLECTOR/DRAIN/ANODE

The COLLECTOR/DRAIN/ANODE connector is connected inside the adapter panel to the collector terminal of the test adapter connector.

(56) COLLECTOR/DRAIN/ANODE SENSE

The COLLECTOR/DRAIN/ANODE SENSE connector is connected inside the adapter panel to the collector sense terminal of the test adapter connector.

(57) EMITTER/SOURCE/CATHODE

The EMITTER/SOURCE/CATHODE connector is connected inside the adapter panel to the emitter (or equivalent) terminal of the test adapter connector.

(58) EMITTER/SOURCE/CATHODE SENSE

The EMITTER/SOURCE/CATHODE SENSE connector is connected inside the adapter panel to the emitter sense terminal of the test adapter connector.

(59) BASE/GATE 1 K OHM

The BASE/GATE 1 K OHM connector is connected inside the adapter panel through a 1 kΩ resistor to the base terminal of the test adapter connector.

(60) BASE/GATE

The BASE/GATE connector is connected inside the adapter panel to the base terminal of the test adapter connector.

(61) BASE/GATE SENSE

The BASE/GATE SENSE connector is connected inside the adapter panel to the base sense terminal of the test adapter connector.

(62) Test Adapter Connector

A test adapter plugs into the test adapter connector. These connections are wired inside the adapter panel to connectors 55 - 61.

READOUT DISPLAY

The readout display shown Figure 4-11 consists of a graticule area and an area that displays various setups and measurement information. Display information consists of the following:
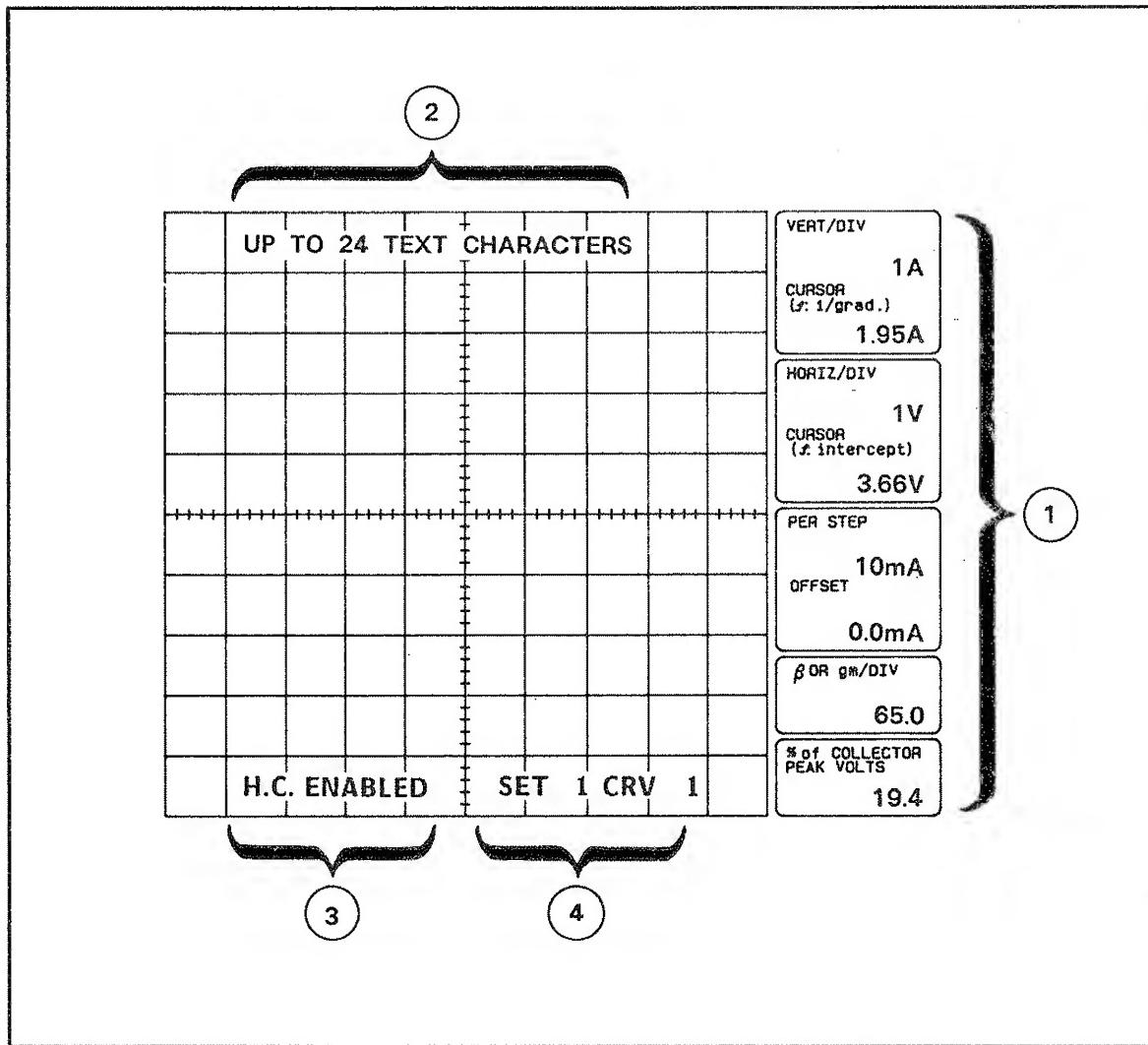
Figure 4-11. Display Screen.

(1) SETUP AREA

The setup display area provides readouts for VERT/DIV, HORIZ/DIV, PER STEP, OFFSET, ß or gm/DIV, % of COLLECTOR PEAK VOLTS, and cursor measurement readouts for vertical and horizontal axes.

When the reference curve is displayed, readout data of the store or view curve are displayed in these readout areas; not the readout data for the reference curve. Refer to "Reference (REF) Display Mode" in Section 2: General Operation for additional information.

(2) TEXT AREA

The location that displays up to 24 characters of user selectable text.

(3) MESSAGE AREA

System messages (such as OPERATION ERR, SAVE COMPLETE, CHECKSUM ERROR, ERASE COMPLETE, etc.) are displayed in this area for about five seconds and are then automatically erased.

(4) SETUP/CURVE ID AREA

The memory location of the curve currently displayed is identified by pressing the VIEW button. This memory index number is called the curve ID (identification).

The memory location of setup information for the currently displayed curve is identified on the display by pressing the RECALL button. This memory index number is called the setup ID.

The curve ID and setup ID are removed from the display when a front-panel setting is changed or after five seconds have elapsed.

Chapter 5
GPIB

This chapter describes the GPIB Interface used by the 371A. Information is presented in the following order:

* review of GPIB principles

* interface capabilities

* system setup and configuration

* controlling the 371A over the GPIB

* device-dependent message format

* front-panel settings and corresponding GPIB commands

* command reference (command descriptions)

* service requests

REVIEW

The General Purpose Interface Bus, or GPIB, is a standardized, digital interface for interconnecting up to 15 self-contained instruments, controllers, and other devices. The instruments may be units such as the 371A High Power Curve Tracer, signal generators, digital multimeters, or digital oscilloscopes. The ANSI (American National Standards Institute) and IEEE (Institute of Electric and Electronic Engineers, Inc.) standards define two aspects of the interface: the hardware and a basic communication protocol.

Hardware

The hardware consists of a set of interface circuits in each device, along with standard 24-conductor cabling for interconnecting the devices in a system. Sixteen of the 24 wires are used for signaling: eight for addresses or data, three for handshaking during data transfers, and five for interface management. Most data is transferred as a series of eight-bit bytes over the eight data lines.

Communication Protocol

The basic communication protocol specifies a set of pre-defined interface messages for system organization and housekeeping, but only indicates the basic requirements for communicating other information such as setup commands and measurement results. The protocol does not define the meaning or format of the measurement results, which are termed device-dependent messages.

Meaningful messages for each instrument are specified by the instrument manufacturer and are usually defined in the instrument manual. Tektronix has standardized on a higher level protocol for all its GPIB instruments, called Tektronix Codes and Formats.

A typical GPIB system will include a controller and one or more instruments, such as the 371A. Some instruments are talk-only or listen-only devices while others can both talk and listen. The 371A does both. Linking a controller to the 371A, and possibly other instruments, provides operation in four major task areas:

* program development

* system control

* data processing

* display and storage

These four tasks are discussed in the following paragraphs.

Program Development

Program development includes writing, editing, and debugging the programs needed to control the instruments in the system.

System Control

While running a program, the controller assigns tasks to instruments in the system, coordinates communication, handles error conditions, and monitors the system's progress.

This instrument control task can be further divided into six functions:

* addressing instruments

* sending commands

* transmitting and receiving data

* handling interrupts

* data processing

* display and storage

Each of these system control functions are explained below.

Addressing Instruments. The controller selects an instrument by addressing it. Each instrument on a bus is assigned a unique primary address in the range 0 through 39. The controller uses this address to set an instrument to talk or listen.

Sending Data and Commands. Device-dependent messages carry commands and data from the controller to the 371A and return instrument status information and measurement data. The ATN line (pin 11 of the GPIB) is asserted while interface messages are sent to identify them from device-dependent messages. (See Figure 5-1 for a graphic representation of this interaction.)
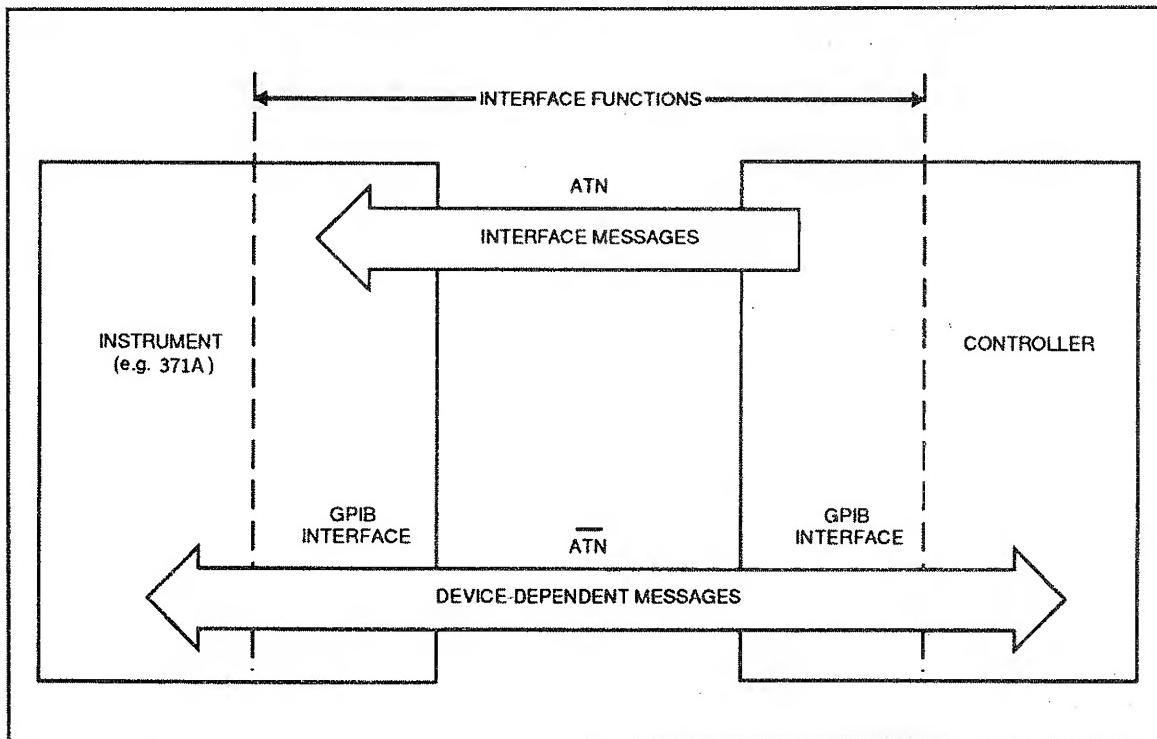
Figure 5-1. GPIB messages.

Interface messages are commands that control interface functions. The IEEE Standard 488 specifies interface messages so that they are the same for all devices.

There are two kinds of interface messages: uni-line and multi-line, where "line" refers to the 16 signal lines within the bus. Multi-line messages can be further subdivided into universal commands, addresses, and addressed commands. Figure 5-2 shows how the different types of GPIB messages are related and indicates the standard three-letter symbols assigned to them.
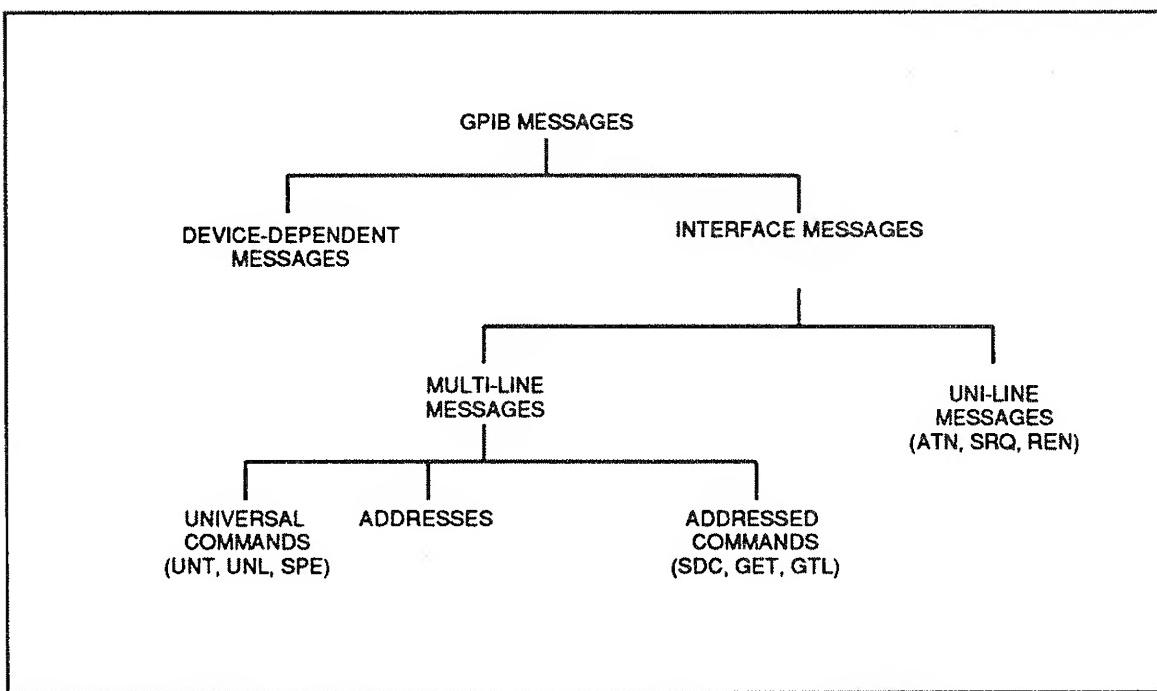
Figure 5-2. GPIB message types.

Multi-line interface messages are sent by placing a byte on the eight data lines of the GPIB and asserting the ATN line. Universal commands affect all devices on the bus while addresses and addressed commands affect only the addressed instruments.

Uni-line interface messages are sent by asserting one of the five individual interface signal lines of the GPIB:

SRQ (service request)

ATN (attention)

IFC (interface clear)

REN (remote enable)

END (EOI, end or identify)

Device-dependent messages consist of commands or data that control instrument function and communicate instrument status, as well as data from measurements and other information. As noted before, the content and format of these messages has been addressed with Tektronix Codes and Formats. All of these message types are significant for the 371A.

Transmitting and Receiving Data. Most instruments talk (send data) and listen (receive data) to the system controller. The 371A does both. In fact, the 371A sends and receives two classes of data: instrument setups and measurement results. There are various ways of coding such data. The 371A, in keeping with Tektronix Codes and Formats, uses English keywords for setup and status data and a combination of similar keywords and a form of binary-coded numbers for measurement data.

Handling Interrupts. The 371A and other devices in the system can generate interrupts to inform the controller of conditions warranting some sort of attention, such as an error condition or the completion of an operation. The controller polls the devices on the bus to find the source of the interrupt, reads its status, and takes appropriate action.

Data Processing. Still another major task of a GPIB system is processing the data acquired from instruments. Examples of this processing are extracting key parameters from a family of curves and deciding whether some pass-fail criterion has been exceeded.

Display and Storage. Once data has been sent to the controller it can be stored or displayed, as well as processed. The controller console screen is one place data may be displayed.

INTERFACE CAPABILITIES

IEEE Standard 488 defines a variety of possible interface capabilities for differing needs among various controllers and instruments.

Table 5-1 summarizes the capabilities available in the 371A. The abbreviations are detailed in the IEEE standard.

Table 5-1
GPIB Interface Specifications

Function	Subset	Note
Source Handshake	SH1	Complete capability
Acceptor Handshake	AH1	Complete capability
Talker	T6	Basic Talker, Serial Poll, Talk Only, Unaddress if MLA
Listener	L4	Basic Listener, Unaddress if MTA
Service Request	SR1	Complete capability
Remote/Local	RL2	Complete capability
Parallel Poll	PP0	No capability
Device Clear	DC1	Complete capability
Device Trigger	DT0	No capability
Controller	C0	No capability

Interface Messages

The following explains how the curve tracer reacts to standard interface messages. (Abbreviations are from IEEE Standard 488.) As noted before, a uni-line message is sent over a dedicated line and a multi-line message is sent using the eight data lines while the ATN line is asserted. In the following descriptions, uni-line messages are described as having the appropriate line asserted. Multi-line messages are described with their respective ASCII code and decimal value for the eight-bit byte expressed on the eight data lines.

Due to the set of interface functions required for the 371A, not all of the possible interface messages would be meaningful. The 371A does not respond to the following interface messages:

GET   Group execute trigger
PPC   Parallel poll configure
PPU   Parallel poll unconfigure
TCT   Take control

It does respond to or use the following interface messages, as described.

My Listen and My Talk Address (MLA and MTA)

The address of the 371A is established by setting the address select switches on the rear panel. When the 371A receives its own address along with either of these commands, it responds by entering the appropriate state: ready to talk or ready to listen.

Attention (ATN)

With the ATN line asserted, data on the eight data lines is interpreted as an address or interface message. With most controller programming languages, operation of the ANT line is transparent to the user.

Unlisten (UNL) and Untalk (UNT)

When the unlisten (UNL) message (ASCII "?", decimal 63) is received, the 371A listen function is placed in an idle (unaddressed) state. In the idle state, the 371A will not accept messages over the GPIB. The talk function is placed in an idle state when the curve tracer receives the untalk (UNT) message (ASCII "_", decimal 95). In this state the 371A cannot transmit data via the GPIB.

Interface Clear (IFC)

When the interface clear (IFC) line is asserted, both the talk and listen functions are placed in an idle state. This produces the same effect as receiving both the untalk and unlisten commands. It resets the interface only, clearing the input and output buffer, and does not affect any instrument functions. This can be used to restart communication with the 371A.

Device Clear (DCL)

The device clear (DCL) message (ASCII "Control T", decimal 20) reinitializes communication between the 371A and the controller. In response to device clear, the 371A clears any input and output messages as well as any unexecuted control settings. Any errors and events waiting to be reported, except power-up, are also cleared. If the SRQ line has been asserted for any reason other than power-up, it becomes unasserted when DCL is received.

Selected Device Clear (SDC)

The selected device clear (SDC) message (ASCII "Control D", decimal 4) performs the same functions as DCL. However, only instruments that have been listen-addressed respond to SDC.

Go To Local (GTL)

The go to local (GTL) message (ASCII "Control A", decimal 1) takes the 371A "off the bus" and turns off the front-panel REMOTE indicator, just as the front-panel LOCAL button does.

Remote Enable (REN)

When the remote enable (REN) line is asserted and the instrument receives its listen address (MLA), the 371A is placed in its remote state (REMS) and the front-panel REMOTE indicator is turned on.

Service Request (SRQ)

The service request (SRQ) line is set by the 371A each time it has a change in status to report to the controller, or when an operator presses the front-panel USER REQUEST/ID button.

Serial Poll Enable and Disable (SPE and SPD)

The serial poll enable (SPE) message (ASCII "Control X", decimal 24) causes the 371A to transmit its serial-poll status byte when it is talk addressed. The serial poll disable (SPD) message (ASCII "Control Y", decimal 25) switches the 371A back to normal operation.

End Or Identify (END or EOI)

The 371A or controller sets end or identify (EOI) simultaneously with the last byte of the command or data if line feed (LF)/EOI is currently selected as the message terminator. If LF alone is selected, the message terminator is LF accompanied by EOI and followed by a carriage return (CR).

Local Lockout (LLO)

When a local lockout (LLO) message (ASCII "Control Q", decimal 21) is received, the 371A enters the lockout state.

NOTE

The 371A has no front-panel lockout indicator to indicate when lockout is set. Once set, all subsequent inputs from front-panel keys with corresponding remote commands will be ignored.

Device-Dependent Messages

Device-dependent messages for the 371A are in three categories: commands and queries, setup data, and measurement data.

Commands and Queries

Commands are sent to the 371A to initiate some action or to change its settings. Some commands may be as short as three characters. Other more complex commands may be much longer.

A notable subcategory of commands is that of query commands or queries. The 371A responds to a query by sending another device-dependent message back to the controller. This response communicates the appropriate instrument status, settings, or measurement data. These messages may also vary from a few characters to many characters in length.

Setup Data

Since most front-panel settings are programmable, a series of commands can set up the 371A for a particular measurement. In fact, a group of individual settings or an entire front-panel setup can be strung together and sent as a single message.

Queries can be used, in turn, to send individual settings or to complete front-panel setups back to the controller. This means a setting can be made manually and then stored using the bus controller, providing an alternative to storing the setting in the 371A mass storage.

Measurement Data

Usually the most significant data available from the 371A are sets of characteristic curves from a DUT. For any given measurement this data is packaged in two parts: a preamble and a curve. Preambles and curves can be read from the 371A into the controller either separately or combined. Later they can be loaded back into the 371A for further use.

The preamble (the front-panel setup information) contains the information needed for interpreting, scaling, and labeling the numeric information in the curve. This preamble is coded in ASCII characters and is readable by the operator without interpretation by the controller.

The curve is a series of binary-coded numbers expressing the X-Y coordinates of the digitized points (up to 1024) representing the displayed curves. These binary-coded numbers are interpreted by the controller.

Two types of data that can be read from the 371A are: the coordinates of a cursor located on the curves, and the text shown in the text-display area of the screen.

SYSTEM SET UP AND CONFIGURATION

The first steps in putting the 371A to work in a system are:

1. setting the bus address

2. choosing the message terminator

3. connecting the GPIB cable

4. powering up

These steps are discussed in the following paragraphs.

Setting the Bus Address

The 371A has a configuration switch bank on the rear panel which is used to set the bus address and message terminator (shown in Figure 5-3).
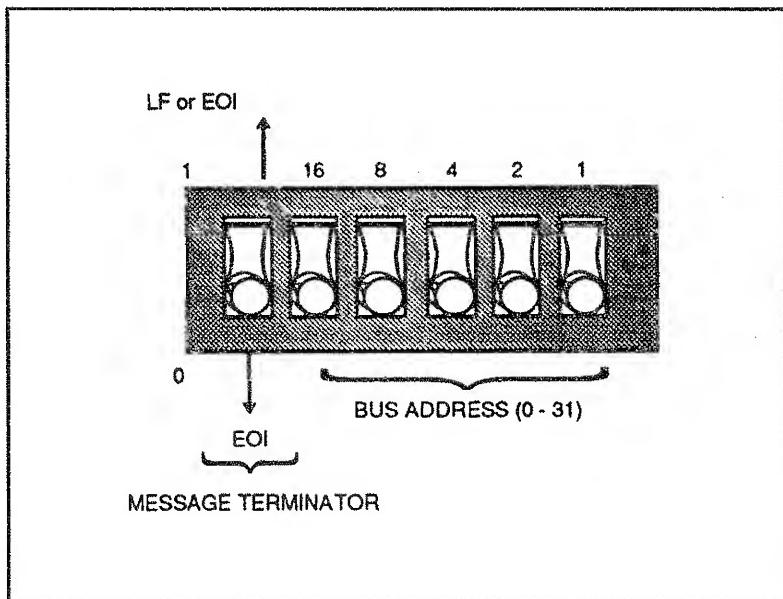
Figure 5-3. Rear panel configuration switch.

Each instrument connected to the bus must have a unique address. This address is used by the controller to direct the flow of data to and from that specific device.

When choosing a bus address for the instrument, remember:

* The address of the 371A must be unique on the bus.

* Some controllers reserve an address for themselves.

* Selecting an address of 31 logically removes the 371A from the bus. It does not respond to any GPIB commands. It remains both unlistened and untalked.

* The 371A uses primary addressing only. Sending a secondary address will have no effect.

* The address setting can be verified or changed by examining or setting the address switches located on the rear of the 371A (shown in Figure 5-3).

The address can also be verified by simultaneously pressing the front panel cursor SHIFT button and GPIB ADDR button. The message terminator and bus address appear in the error message area of the 371A display.

Choosing the Message Terminator

The message terminator is used to indicate the end of message transfer. The two most common terminators are the end or identify (EOI) signal line and the line feed (L character.

If EOI is selected, the 371A asserts the EOI line simultaneously with the last data byte when sending a message, and will recognize the EOI line as the terminator when receiving a message. If LF is selected, a carriage return (CR) and LF are sent following the last data byte. The EOI line is asserted simultaneously with the LF character.

When receiving a message, the 371A terminates the message upon receipt of either the LF character or the assertion of the EOI line.

The best way to determine which terminator to use the same terminator used by the system controller.

The terminator can be set with the terminator switch on the rear-panel configuration switch bank (shown in Figure 5-3).

Reading In the Switch Settings

The switch settings are read by the 371A processor only at power-up or when the message terminator and bus address are displayed on the CRT. Therefore, when switches are changed while the power is on, you must simultaneously press the cursor SHIFT and GPIB ADDR keys to make the switch change effective.

Connecting the GPIB Cable

The 371A is attached to the GPIB using a standard GPIB cable. A GPIB system may be connected in two general configurations; a star or line as shown in Figure 5-4.
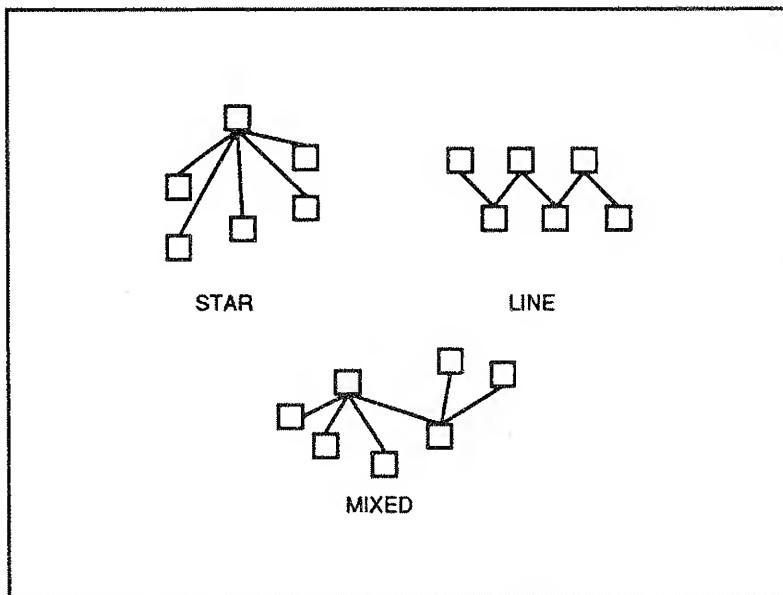
Figure 5-4. Bus configurations.

While the star configuration is recommended, configurations can be mixed as long as the total cable length does not exceed 20 meters and the instruments are distributed on the bus according to a few basic rules:

* No more than 15 total devices, including the controller, can be included on a single bus.

* One device load must be connected for every two meters of cable to maintain proper electrical characteristics.

* Each instrument represents one device load on the bus. The 371A represents one device load.

Powering Up

With the 371A connected by GPIB cable to the system and the address and message terminator has been set, the system is ready to power up. Powering up the 371A as part of a GPIB system involves special considerations, as detailed in the following paragraphs.

Powering Up the System Controller and Other Devices

Remember, when powering up a system with several instruments on the bus, at least half of the instruments must be powered up before the controller is brought "on-line."

Self-Testing

To turn on the 371A, press the front panel POWER switch. The 371A performs a self-test on powering up and initializes itself to a pre-defined state, after which it is ready to make measurements. For details regarding the power-up tests, refer to Appendix B: Diagnostics. The power-up default state for the 371A is the same as the state set by the INIt command described under "Instrument Parameter Commands" in the "Command Reference" section in this chapter.

Power-Up SRQ

When the power-up tests have been completed, the 371A asserts the GPIB line called SRQ. In the interface, the status byte is set to 65.

CONTROLLING THE 371A OVER THE GPIB

As explained in the following discussions, a controller can

* send commands to the 371A

* send queries and receive responses

* control 371A settings

* store and transfer 371A data

* move waveform data from the 371A

* load waveform data to the 371A

* transfer cursor and readout data to and from the 371A

Sending Commands to the 371A

Most GPIB system controllers and their languages provide high-level statements for sending device-dependent messages, such as commands, to any system instrument, including the 371A. These high-level statements usually consist of three parts:

* A keyword (PRINT, OUTPUT, WRITE, etc.) which causes the action (sending the message over the bus) to occur.

* An address or logical unit number which directs the message to a specific instrument.

* The device-dependent message which is the actual command, query, or data to be recognized by the instrument. (Most controllers delimit the device-dependent message with double quotes.)

The following examples show command strings for two controllers and a representative language for each. The first is an IBM PC with a Tektronix GURU card (or National Instruments model PC2 or PC2A card) running BASICA. The second is a Hewlett Packard 200 or 300 Series Scientific Computer running Series 200 or 300 BASIC.

In these examples, the 371A device-dependent command WINdow (abbreviated as WIN) is used to set the window cursor to midscreen. In the second examples, the GPIB address of the 371A is assumed to be "8".

IBM PC: (The address is assigned elsewhere in the code.)

```
220 WRT$="WIN 250,250,750,750"              | Create Command
                                              string.

230 CALL IBWRT(DSO%,WRT$)                   | Send command.
```

Hewlett Packard 200/300 Series:

```
220 OUTPUT 708; "WIN 250,250,750,750 ,END
```

A useful addressing variation assigns the 371A address to a variable and uses that variable in place of the specific numeric address. In the following examples, the address is set to "6". This method works for both example controllers when running BASIC and allows the destination of several commands to be altered by changing only the value of one variable (this is the scheme used in the IBM PC with the GURU card, running BASICA).

Hewlett Packard 200/300 Series:

```
720 DEVICE=706
730 OUTPUT DEVICE; "WIN 250,250,750,750" ,END
```
or
```
720 ASSIGN @DEVICE TO 706
730 OUTPUT @DEVICE; "WIN 250,250,750,750" ,END
```

The examples in Table 5-2 show how the syntax of several different controllers can vary.

Table 5-2
Controller Output Syntax

Controller PC with BASICA	Output Command
IBM PC with BASICA	WRT$="string". CALL IBWRT(DEV%,WRT$)
HP 200/300 Series BASIC	OUTPUT 710;"string",END
HP 9825/200-Series HPL	wrt 710,"string"

Sending Queries and Receiving Responses

Commands with a question mark (?) are query commands which solicit information from the 371A. After the controller sends a query command, it must acquire the resulting response from the 371A. Examples using the HOR? query command follow.

IBM PC:

```
150  WRT$="HOR?"
160  CALL IBWRT(DSO%,WRT$)                    | Send query.
170  RD$=SPACE$(100)
180  CALL IBRD(DSO%,RD$)                       | Input response
```

Hewlett Packard 200/300 Series:

```
150  DIM SET$(100)
160  OUTPUT 710;"HOR?",END
170  ENTER 710;SET$
```

In these examples, a string is dimensioned to 100 characters in order to store the incoming information. The controller sends HOR? over the bus to the 371A located at primary address 10. The controller then assigns the instrument at address 10 to be a talker and inputs the characters into the target variable, SET$. The following shows a possible response, which is an 18-character string. The variable, SET$, now contains this string of characters showing the current status of the horizontal controls:

```
HORIZ COLLECT:1E-1
```

Most commands have a corresponding query command. See "Command Reference" in this chapter for examples. Table 5-3 shows how query responses are input from a variety of controllers.

Table 5-3
Controller Input Syntax

Controller Language	Input Command
IBM PC with BASICA	CALL IBRD$(DSO$,RD$)
HP 200/300 Series BASIC	INPUT 710;S$,END
HP9825/200 Series HPL	red 710,S$

Instrument Setup Over the Bus

One popular use of the GPIB with the 371A is to store front-panel settings for later recall. These stored settings are then used to set up the curve tracer for repeating specific tests. This is accomplished by using a query command to acquire from the 371A an ASCII string representing the front-panel setup. This string is saved by the controller. Later, this same setup can be restored by sending the stored string back over the bus to the 371A.

Storing Settings for the 371A

When a setting is transferred, it must first be moved to the front panel. From there it may be moved to the controller or to the 371A mass storage. Figure 5-5 shows the transfer routes and the commands.
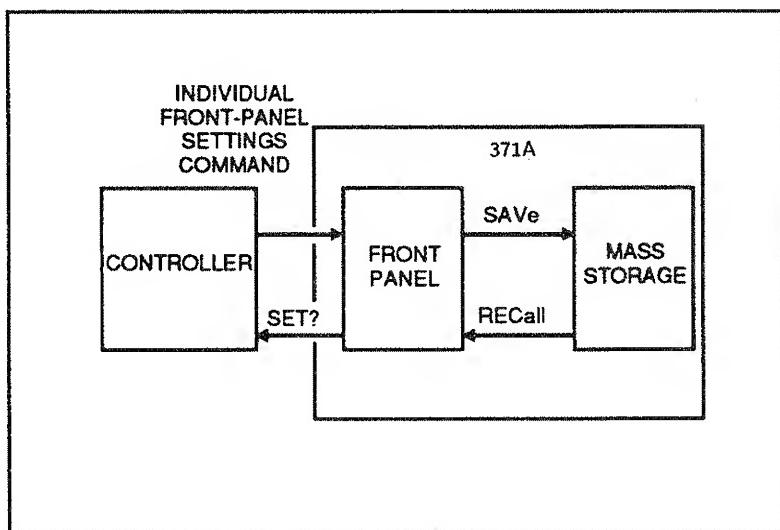
Figure 5-5. Transfer of settings.

To bring the 371A front-panel setting data into the controller, use the **SET?** query and put the response into a string variable or variables that can hold up to 500 characters. From there it can be stored on any medium available to the controller, such as magnetic tape or disk.

IBM PC:

NOTE

BASICA is limited to a 255 character maximum string so the IBRD command will have to be executed twice to take in the full possible extend of the settings string.

```
400 WRT$="SET?"                    |Set up query command
                                    string.
410 RD $=SPACE$(250)               |Assign space for a
                                    250 character
                                    response string.
420 RD2$=SPACE$(250)               |Assign space for a
                                    250 character
                                    response string.
430 CALL IBWRT(DSO%,WRT$)          |Send query.
440 CALL IBRD(DSO%,RD$)            |Input response for
                                    first 250 characters.
450 CALL IBRD(DSO%,RD2$)           |Input response for
                                    remaining characters.
```

Hewlett Packard 200/300 Series:

```
400 DIM SET$(500)
410 OUTPUT 710;"SET?",END
420 ENTER 710;SET$
```

A settings string that is stored by the controller can, of course, be modified. Use the appropriate string manipulation commands in the controller language to search for, modify, or replace parts of the string. Be sure that the resulting string meets the syntax requirements of the 11 individual commands making up the whole and that they are in the proper sequence. See "Command Reference" in this chapter for details.

The following examples use the settings strings that were saved in the preceding set of examples.

IBM PC:

```
700 CALL IBWRT(DEV%,SETA$)
710 CALL IBWRT(DEV%,SETB$)
```

Hewlett Packard 200/300 Series:

```
700 OUTPUT 710;SET$,END
```

If the settings were stored in mass storage, it's necessary to know which one of the 80 memory locations was used. Then send the command RECall <NR1>, where the number, <NR1>, identifies memory location.

While these procedures can change settings quickly and without error, the operator may have to make manual settings (such as setting the collector supply circuit breakers and opening or closing the protective cover). One way to remind the operator what needs to be done is to send a message using the text display area of the 371A screen. Send an appropriate message of up to 24 characters using the TEXt <string> command.

Data Storage and transfer

Once the 371A has been set up to make a desired measurement, the next step in realizing the advantages of digital storage is to acquire and store the data with the 371A. This in turn allows you to plot it, if you have an attached plotter, or copy it into the controller or mass storage. From the controller you can store it on other media, compare it with other data, calculate with it, or display it. Figure 5-6 shows possible routes for data transfers.
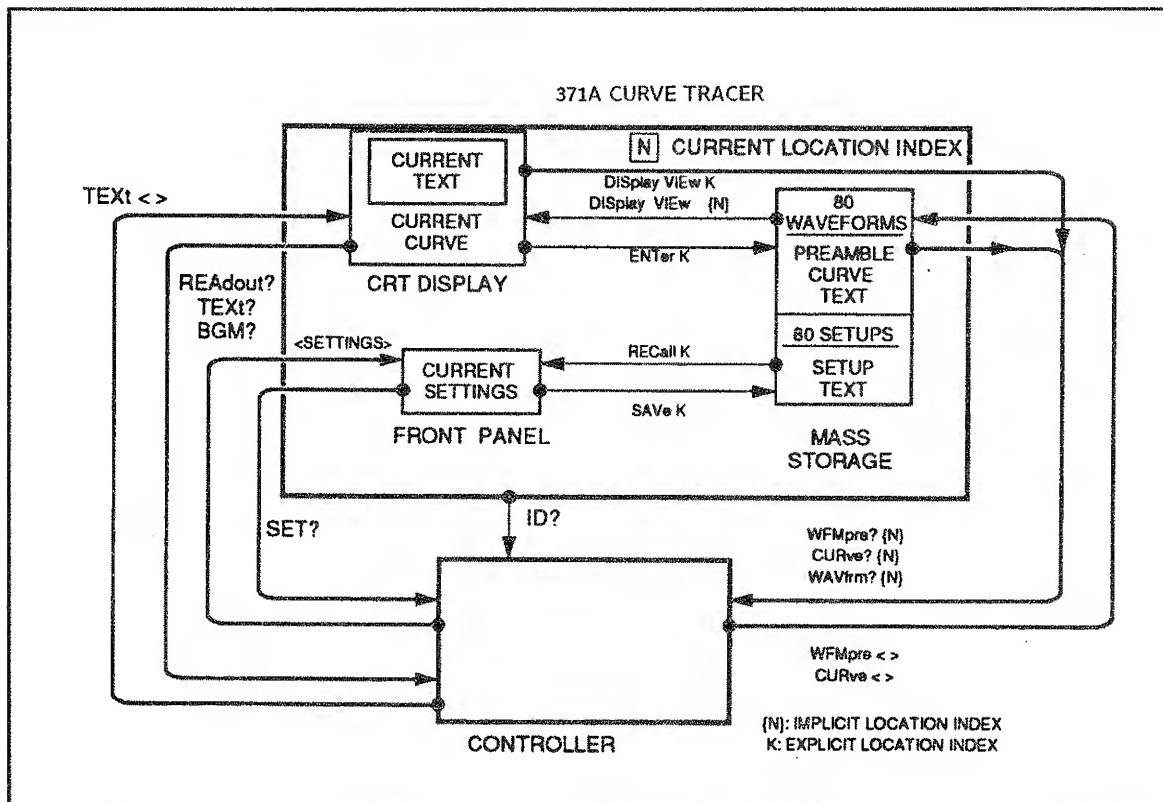
Figure 5-6. Data transfer under GPIB control.

In most cases, acquiring data with the 371A involves two parts, both done automatically by the instrument. The first part of data acquisition is to code the necessary scale factors and other parameters into a series of words and numbers. The words are English but are standardized so they can also be read by a computer. This part of the data is called the "preamble." This information constitutes the front-panel setup information.

The second part of data acquisition is to digitize and code the displayed curves. This converts the curves to a series of binary numbers representing the horizontal and vertical locations of a sequence of points along the curve. This part of the data is called the curve. Together with the preamble it fully describes the displayed curve.

Acquiring Data Within the 371A

To acquire data, set the display function to store mode. The command to do this over the bus is **DISplay STOre**. At this point the current setup information is recorded and the curves being shown are digitized. They can be copied over the bus to the controller or to an attached plotter.

Data Structure

The preamble and curve are each a string of eight-bit bytes. The preamble is a string of ASCII letters, numerals, and punctuation. Each character is represented by one byte. The major part of a curve is a sequence of binary-coded numbers, which is prefixed by a 25-character ASCII string identifying the curve.

The curve data string represents the 371A display, where each data point in the display is described as a 10-bit horizontal and 10-bit vertical position. The horizontal and vertical positions are each coded as a pair of bytes in the data string. Thus, there are four bytes for each data point. Since a display can have from one to 1024 data points, the curve data can include from four to 4096 bytes. In addition, there are two bytes at the start of the string for a byte count and one byte at the end for a checksum value, for a maximum of 4099 bytes.

The numbers are coded in two's complement binary format. The low-order eight bits are stored in the second byte while the two high-order bits are stored in the low-order positions of the first byte. The sign bit fills the remaining bits in the high-order byte.

Moving Waveform Data to the Controller

Waveform data is transferred from the 371A to the controller in two parts; the preamble and the curve data. As explained in the following discussions, these two parts can be transferred together or separately.

Transferring the Preamble

To receive a waveform preamble from the 371A, send the command query WFMpre?. The response will be a string containing 17 parameters, each shown as a label and value pair. (Refer to the "Command Reference" in this chapter for details.) Follow the command query with an instruction to the controller to input the response, allowing for a string about 320 characters long.

Hewlett Packard 200/300 Series:

```
300 DIM PREAM$(320)
310 OUTPUT 718;"WFM?",END
320 ENTER 718;PREAM$
```

Transferring the Curve

Before a waveform can be transferred to the controller, it must first be displayed. When a waveform is transferred from the controller it must go directly to a 371A mass storage index location. The routes and commands are shown in Figure 5-7.
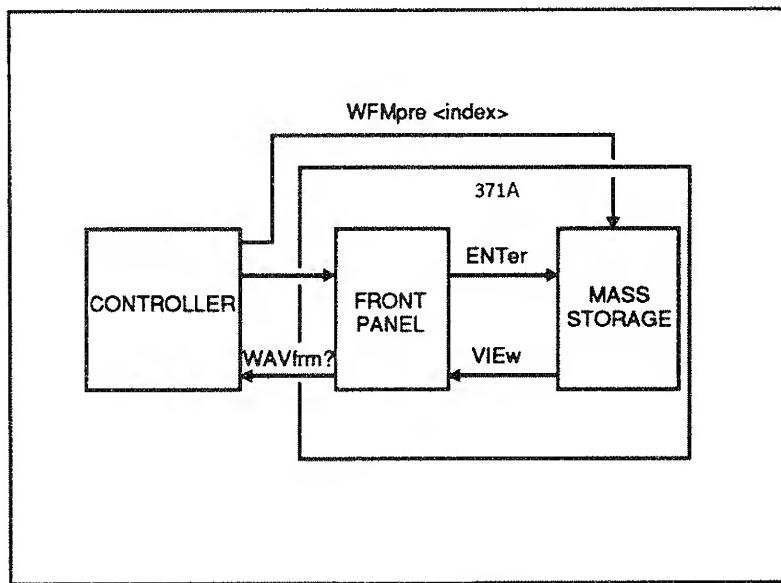
Figure 5-7. Transfer of curves.

To copy displayed data in store or view mode to the controller, first send a WFMpre? to transfer the preamble. Then send a CURve? query to transfer the curve.

To copy the data from mass storage to the controller, first send a DISplay VIEw:<index> command to display the curve stored at the index location. Then send a WRMpre? query to transfer the preamble from the display. Last, send a CURve? query to transfer the curve from that location. Another command, WAVfrm?, combines the functions of WFMpre? and CURve? and returns the preamble and curve strings, with an ASCII semicolon to separate the two strings.

For the curve data, in general, you will have to make provisions for a string length of about 4125 bytes. The response will be a short ASCII string (25 bytes or characters) identifying the curve, two bytes giving the number (in binary) of data points to follow, the 4096 bytes representing the actual curve data, and a checksum (one binary byte).

Transferring the Waveform to Mass Storage

Another possibility for storing data under control of the bus is to put the waveform in a storage location in mass storage. Use the ENTer <NR1> command, where the number, <NR1>, is the storage location number.

Loading Data from the Controller

Moving display data from the controller to the 371A waveform storage location of 17 through 80 (storage locations reserved for the floppy disk) requires that an unlocked floppy disk be installed in the 371A floppy disk drive unit.

NOTE

Data transferred from the 371A in Store mode cannot be reloaded to the 371A.

Loading the Preamble

The command WFMpre <string>, where <string> is a waveform preamble, will load that preample into the 371A. The preamble will be stored in the waveform storage location indicated by the WFID INDEX portion of the string. (See WFMpre in "Command Reference" in this chapter for details.)

Loading the Curve

NOTE

When sending the display data to the 371A, the target is the waveform storage location set by the preceding preamble transfer.

To send a curve from the controller to the 371A, use the command CURve <string>, where <string> consists of a short ASCII string (which identifies the curve) followed by a string of binary bytes. See CURve in "Command Reference" in this chapter for details.

Transferring Other Types of Data

Although waveforms are the principle data developed with the 371A, there are two other types of data: cursor readout and text.

Transferring the Cursor Readout

The point at which a dot cursor is located on the display can be expressed in terms of display units. The data is requested with the REAdout? command and the response is the word READOUT followed by a pair of numbers giving the cursor location in terms of physical units: horizontal location in volts and vertical location in amperes. With the f line cursor activated, the response to the REAdout? query gives either the cursor 1/gradient in ohms or gradient in siemens abbreviated as "S", and the horizontal intercept in volts. The window cursor can be used similarly but the readout value depends on the last manual setting as to whether it comes from the top right or bottom left corner of the rectangular window cursor.

Transferring Text

Although it's not data in the same sense, information in the text display can be read over the bus with the TEXt? query command. Text can also be replaced in the display with the TEXt command, as described in "Command Reference" in this chapter.

DEVICE-DEPENDENT MESSAGE FORMAT

Device-dependent messages travel both ways between the instrument and controller, and are used to

* set instrument controls

* request and return the instrument status

* request, return, and send waveform

* request and return results of other measurements

Most messages are sent as strings of ASCII characters; however, data representing sets of curves are sent as series of binary-coded numbers.

Commands are sent from the controller to the instrument. Each starts with a keyword called a header which is usually followed by an argument to further detail the instruction. The keywords used for command headers and arguments are mnemonics related to specific instrument controls and functions. Multiple commands can be sent in one message. Many command headers can be issued with an attached question mark (?), identifying them as queries which prompt the instrument for certain information.

Response to queries either contain information about instrument status or measurement data. Generally, status messages are made up of the same keywords used for commands. The only device-dependent messages not made up of words or parts of words are those made up of curve data.

Each message ends with the message terminator, which was discussed earlier. In most cases the controller or its language takes care of the message terminator and it is no longer a concern once it has been chosen and set.

Command Message Formats

Commands for the 371A, like those for other Tektronix GPIB instruments, follow the conventions of the Tektronix Standard Codes and Formats. Each command starts with a keyword header which is often followed by one or more keyword arguments to further specify the action to be taken. The keywords for the commands were chosen to be as understandable as possible, while still allowing a user familiar with the commands to shorten most of them to only a few characters. Syntax is also standardized to make the commands easier to learn.

In most of this chapter, keywords for headers and arguments are listed in a combination of uppercase and lowercase letters. The instrument accepts any abbreviated header or argument containing at least all the characters shown in uppercase. We show them as uppercase and bold font to emphasis the minimum number of characters that will be recognized as the command. *The 371A accepts upper or lower case characters.* In many cases, the commands may be expressed in a variety of valid ways. For example, the following are all valid versions of the INIt command, which resets the 371A to the initial state following power-up.

        INI
        INIT
        Ini
        Init
        ini
        init
        inIT

"Command Reference" in this chapter describes all the 371A commands and queries. In "Command Reference", the elements of each command and query are listed in tabular format. The first column lists the header keyword. The second column lists arguments that may be associated with the command. A third column, lists linked arguments, if used. Brief descriptions and examples are shown in the last column.

Headers

Each command consists of at least a header.

        <header>

Each command header is unique and in some cases is all that is needed to invoke the command. For example:

    INIt

NOTE

CURSor can be shortened only to four characters. If you try to shorten to three characters CUR will be interpreted as CURve.

Arguments

Many commands require the addition of arguments to the header to describe exactly what is to be done. If there is more to the command than just the header, the header must be followed by at least one space. Otherwise, the 371A treats all spaces, linefeeds, and tabs as "white space" and ignores them in analyzing messages from the controller. For example:

```
<header> <argument>
```

In some cases, the argument is simply a single word or a number. For example:

```
CURSor OFF
RQS on
PKPower 3000
```

Linked Arguments

In other cases, the argument itself requires another argument. When an argument to an argument is required, a colon links the two; hence, the second argument is called a linked argument. For example:

```
<header> <argument>:<linked argument>

DISplay INVert:ON
VERt COLlect:1.0E+0
WFMpre NR.PT:512
```

Queries

For most commands there is a corresponding query formed by adding a question mark to the header keyword. Do not put a space between the last character of the keyword and the question mark.

Queries for the 371A need only the header and question mark, though the response will usually be more involved.

```
<header>?

ID?
HOR?
DEB?
STPgen?
```

```
Query:                   STP?
Typical Response:        STPGEN OUT:ON,NUMBER:2,OFFSET:0.00,
                         INVERT:OFF,MULT:OFF,CURRENT:1.0E-3
```

Multiple Arguments

Where a header has multiple arguments, the successive arguments (linked arguments) must be separated by commas.

```
<header> <first arg>:<link arg>,<second arg>:<link arg>

STP CUR:2E-3,MUL:ON,NUM:5
DIS VIE:16,REF:ON
```

Numeric Argument Formats

Many commands have numeric arguments. The numbers are decimal (base10) values. They are expressed in three different formats, denoted <NR1>, <NR2>, and <NR3>. These formats are shown in Table 5-4.

Table 5-4
Numeric Argument Formats

Symbol	Number Format	Examples
<NR1>	Integer	+1, 2, −1, −10, 0
<NR2>	Explicit decimal point	−3.2, +5.1, 1.2, .0, 0.
<NR3>	Floating point, exponential, or scientific notation	−12.3E−2, .005E−6, 0.000E−3 6.7E+4, 2.35E−3, 0.E0, 125E−6

Generally:

An <NR1> argument must be sent to the 371A in that format (i.e., without a decimal point).

An <NR2> argument may be sent to the 371A in either <NR2> or <NR1> format.

An <NR3> argument may be sent in <NR3>, <NR2>, or <NR1> format.

Examples of these argument formats are shown in Table 5-5.

Table 5-5
Argument Format Examples

Command	Valid Forms
RECall <NR1>	REC12
DISplay VIEw:<NR1>	DIS VIE:7
VERt COLlect:<NR3>	VER COL:2
	VER COL:0.51
	vert collect500.0:E-3

Multiple-Command Messages

Multiple commands may be included in one message by separating individual commands
with semicolons. The command examples are shown in different formats to demonstrate the
371A indifference to upper and lower case. For example:

```
<first command>;<second command>;<third command>

PKPOWER 30;CSPOL NPN;MEASURE SINGLE
pkpow 30;cspol npn;meas single
PKP 30;CSP NPN;MEA SIN
CURSOR OFF;HORIZ STPGEN:1.0E+0;STPGEN NUMBER:3
```

With multiple commands in the message, the message terminator is needed only once, at the
end of the message. Most controllers and their languages take care of this.

Other Messages

Besides receiving commands and queries, the 371A can receive data and send responses to
queries. The data and responses can be either quite short (a word and a number) or fairly
long (a full set of front-panel settings). Measurement information can also be either short (a
word and a number) or lengthy (a full display).

ASCII Strings. The only device-dependent messages not sent as ASCII strings are the
binary data used for curves. All other messages, both to and from the 371A, are ASCII
strings made up of numbers or keywords pertaining to the applicable parameters.

Keyword Messages. A sample, keyword exchange resulting in a simple response is the following.

Query:	PST?
Response:	STATUS BUSY

Another example follows, this one resulting in a more lengthy response.

Query:	STP?
Response:	STPGEN OUT:ON,NUMBER:2,OFFSET:1.5,
	INVERT:OFF,MULT:OFF,VOLTAGE:200.0E-3

Number Messages. Numbers other than those representing curves are sent as strings of ASCII characters. Some controllers may require that these be explicitly converted to numeric values for use in calculations. Other controllers or languages may provide a more direct conversion.

Preambles

Preambles are necessary to interpret the numeric information in the curve data that follows them. Within a preamble, 24 parameters are specified. The first eight are unique to the 371A and are included as a substring linked to the WFID: label. The other 16 parameters include 10 parameters that have fixed values and six that vary with the particular data sent.

Within the **WFID:** substring the parameters are separated by slashes, while the entire substring is delimited by a pair of double quote marks. Most of the **WFID:** string is rather strictly defined; for example, each parameter value is right-justified in a fixed length field. An exception is the BGM value, which may vary in field length. The remainder of the preamble uses standard punctuation. A colon links each parameter label with its corresponding value and the individual label and value pairs are separated with commas.

A complete preamble might look like this:

```
WFMPRE WFID:"INDEX 3/VERT 500MA/HORIZ 1V/STEP 5V/OFFSET 0.00V/
BGM 100mS/VCS 12.3/TEXT /HSNS VCE",ENCDG:BIN,NR.PT:3,PT.FMT:XY,
XMULT:+1.0E-2,XZERO:0,XOFF:12,XUNIT:V,YMULT:+5.0E-3,YZERO:0,
YOFF:12,YUNIT:A, BYT/NR:2,BN.FMT:RP,BIT/NR:10,CRVCHK:CHKSM0,
LN.FMT:DOT
```

Curves

Curve data sets are usually much longer than any other kind. Typically a set of curve data will be about 4122 bytes long, with most of the bytes being binary-coded numbers. Thus, most of the string of data is not directly readable, but must be interpreted by the controller.

An example might look like this:

```
CURVE CURVID:"INDEX 9",%NNXXYYXXYY . . . XXYYC
```

This example breaks down as follows. It starts with an ASCII string of 25 characters:

```
CURVE CURVID;"INDEX 9",%
```

This is followed by a series of binary bytes. The first of these is two bytes giving the number of data bytes to follow, plus one (typically 4097):

```
NN
```

Then come the 4096 data bytes. Each of the 1024 data points on the curve is represented by four bytes, two for the 10 bits of the X coordinate and two for the 10 bits of the Y coordinate:

```
XXYYXXYY . . . XXYY
```

And finally, there is one byte which is the checksum for the preceding 4098 data bytes.

FRONT PANEL SETTINGS AND CORRESPONDING GPIB COMMANDS

Most front-panel controls on the 371A can be set with GPIB commands, and the settings of most front-panel controls can be reported back over the bus to a controller.

Table 5-6 contains a listing of all front-panel controls and the associated commands and queries. The groups listed in the last column of the table are explained the "Command Reference" in this chapter.

Table 5-7 contains general setting and command/query information.

Table 5-6
GPIB Commands and Queries for Front-Panel Controls

371A Control	Command	Query	Group
CRT Controls			
NON STORE/STORE/VIEW	none	none	none
Intensity			
REF Intensity	none	none	none
READOUT intensity	none	none	none
FOCUS	none	none	none
GRAT ILLUM	none	none	none
POSITION	none	none	none
TRACE ROTATION	none	none	none
Measurement Controls			
REPEAT	**MEA**sure	**MEA**sure	Miscellaneous
SINGLE	**MEA**sure	**MEA**sure	Miscellaneous
SWEEP	**MEA**sure	**MEA**sure	Miscellaneous
Memory Controls			
Memory location number	Selected only as an argument when saving and recalling settings or waveforms		
Setup Controls			
SAVE	**SAV**e	none	Miscellaneous
FORMAT	none	none	none
RECALL	**REC**all	none	Miscellaneous
DIRECTORY	none	none	none
Display Controls			
NON STORE	**DIS**play	**DIS**play?	Display
STORE	**DIS**play	**DIS**play?	Display
	CURve	**CUR**ve?	Waveform transfer
		WAVfrm?	Waveform transfer
CAL FULL	**DIS**play	**DIS**play?	Display
REF	**DIS**play	**DIS**play?	Display
CAL OFF	**DIS**play	**DIS**play?	Display
VIEW	**DIS**play	**DIS**play?	Display
CAL ZERO	**DIS**play	**DIS**play?	Display
ENTER	**ENT**er	–	Display
TEXT	**TEX**t	**TEX**t?	CRT readout Transfer
HORIZONTAL VOLTR/DIV	**HOR**iz	**HOR**iz?	Display
VERTIBAL CURRENT/DIV	**VER**t	**VER**t?	Display
INVERT	**DIS**play	**DIS**play?	Display

(table continued on next page)

Table 5-6 (cont.)
GPIB Commands and Queries for Front-Panel Controls

371A Control	Command	Query	Group
Collector Supply Controls			
POLARITY	CSPol	CSPol?	Collector supply
PEAKPOWER WATTS	PKPower	PKPower?	Collector supply
VARIABLE	VCSpply	VCSpply?	Collector supply
LOOPING COMPENSATION	none	none	none
Step Generator Controls			
INVERT	STPgen	STPgen?	Step generator
SOURCE	STPgen	STPgen?	Step generator
NUMBER OF STEPS	STPgen	STPgen?	Step generator
STEP/OFFSET AMPLITUDE	STPgen	STPgen?	Step generator
OFFSET	STPgen	STPgen?	Step generator
STEP MULTI.1X	STPgen	STPgen?	Step generator
DISABLE	STPgen	STPgen?	Step generator
Cursor Controls			
Cursor Mode	CURSor	none	Cursor
	DOT	none	Cursor
	WINdow	none	Cursor
	LINe	none	Cursor
Cursor Position		REAdout?	CRT readout Transfer
	DOT	DOT?	Cursor
	WINdow	WINdow?	Cursor
	LINe	LINe?	Cursor
GPIB Controls			
RESET TO LOCAL	none	none	none
ADDR	none	none	none
USER REQUEST	none	none	none
ID	–	ID?	Instrument Parameters
PLOT	PLOt	none	Miscellaneous
CURVE	PLOt	none	Miscellaneous
Signal Output Controls			
Collector supply Breakers	none	CSOut?	Collector supply

Table 5-7
General Setting Information and Related GPIB Commands

Setting Information	Command or Query	Group
Set the 371A controls to the power-up default settings	INIt	Instrument Parameters
What are the current 371A	SET?	Instrument Parameters
What are the valid command	HELp?	Instrument Parameters

COMMAND REFERENCE

The 371A has commands and queries in nine function groups:

- Collector Supply: control and report collector supply settings

- CRT Readout Transfer: read and write display text and report the cursor readout

- Cursor: control and report cursor position and set cursor mode

- Instrument Parameter: initialization, troubleshooting, and status reporting

- Miscellaneous: control and report measurement mode and plotter output, report output connector status, store and recall front panel settings.

- Status and Event: control and report service requests and event codes

- Waveform Transfer: store and recall waveforms

Table 5-8 shows the nine groups and the commands within each group. Detailed descriptions of each command are provided in the order as listed in this table.

The "Command Index" (following Table 5-8) lists all commands and queries alphabetically and gives the page on which they are described.

Table 5-8
Command and Query Groups

Query Group	Command
Collector Supply	CSPo
	CSPol?
	CSOut?
	PKPower
	PKPower?
	VCSpply
	VCSpply?
CRT Readout Transfer	BGM?
	REAdout?
	TEXt
	TEXt?
Cursor	CURSor
	DOT
	DOT?
	LINe
	LINe?
	WINdow
	WINdow?

Table 5-8 (cont.)
Command and Query Groups

Query Group	Command
Display	DISplay DISplay? ENTer HORiz HORiz? VERt VERt?
Instrument Parameter	DEBug DEBug? HELp? ID? INIt SET? TESt?
Miscellaneous	MEAsure MEAsure? OUTputs? PLOt PSTatus? RECall SAVe
Status and Event	EVEnt? OPC OPC? RQS RQS?
Step Generator	STPgen STPgen?
Waveform Transfer	CURve CURve? WAVfrm? WFMpre WFMpre? WFMpre NR.PT WFMpre? NR.PT

Command Index

The following is an alphabetical index of the command reference descriptions:

Collector Supply Commands and Queries

The Collector Supply group of commands and queries sets and reports the status of the collector supply polarity, mode, peak power, and output level. They also query the 371A on the status of the collector supply HIGH CURRENT and HIGH VOLTAGE breakers, which cannot be set via the GPIB.

The commands and queries in this group include:

CSOut?
CSPol
CSPol?
PKPower
PKPower?
VCSpply
VCSpply?

An alphabetical listing of all command and query headers is given in the "Command Index ."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

CSOut?

Group: Collector Supply

Purpose: Queries the 371A for the current setting of the collector supply HIGH VOLTAGE and HIGH CURRENT breakers.

Header	Argument	Definition and Syntax
CSOut?		Respond with the collector supply breaker status.
		Response syntax: **CSOUT \<mode\>** Where: **\<mode\> =** **BOTH** or **VOLTAGE** or **CURRENT** or **OFF** and **BOTH =** Both the HIGH VOLTAGE and HIGH CURRENT breakers are enabled. **VOLTAGE =** HIGH VOLTAGE breakers is enabled and HIGH CURRENT breaker is disabled. **CURRENT =** HIGH CURRENT breaker is enabled and HIGH VOLTAGE breaker is disabled. **OFF =** Both the HIGH VOLTAGE and HIGH CURRENT breaker are disabled.

CSPol

Group: Collector Supply

Purpose: Sets the collector supply polarity and mode.

Header	Argument	Definition and Syntax
CSPol	NPN POSitive PNP NEGative	Select the collector supply polarity and mode.
		Command syntax: CSPol \<mode\> where: \<mode\> = NPN, POSitive, PNP, or NEGative

CSPol?

Group:	Collector Supply	
Purpose:	Queries the 371A for the current setting of the collector supply polarity.	

Header	Argument	Definition and Syntax
CSPol?		Respond with the collector supply polarity.
		Response syntax: **CSPOL** <mode> where: <mode> = NPN or PNP

PKPower

Group: Collector Supply

Purpose: Selects the collector supply peak power watts setting.

Header	Argument	Definition and Syntax
PKPower	3000 300 30 3 0.3 0.03	Set the maximum peak power, in watts.
		Command syntax: **PKPower** \<set\> where: \<set\> = 3000 or 300 or 30 or 3 or 0.3 or 0.03

PKPower?

Group: Collector Supply

Purpose: Queries the 371A for the current setting of the collector supply peak power watts setting

Header	Argument	Definition and Syntax
PKPower?		Respond with the maximum peak power setting, in watts
		Response Syntax: PKPOWER \<set\>
		where: \<set\> = 3000 or 300 or 30 or 3 or 0.3 or 0.03

GPIB

VCSpply

Group:	Collector Supply	
Purpose:	Sets the collector supply output level	

Header	Argument	Definition and Syntax
VCSpply	\<NR2\>	Sets the collector supply output level (variable). The argument is stated as a percentage with allowed increments of 0.1%.
		Command syntax: **VCSpply \<data\>** where: \<data\> = 0.0 or 0.1 . . . 99.9 or 100.0

VCSpply?

Group: Collector Supply

Purpose: Queries the 371A for the current setting of the collector supply output level.

Header	Argument	Definition and Syntax
VCSpply?		Respond with the collector supply output level (variable) setting.
		Response syntax: VCSPPLY \<data\>
		where: \<data\> = 0.0 or 0.1 . . . 99.9 or 100.0

CRT Readout Transfer Commands and Queries

The CRT Readout Transfer group allows the controller to read horizontal and vertical cursor parameters from the 371A, and to read or write text in the text area of the display graticule.

The commands and queries in this group include:

> BGM?
> REAdout?
> TEXt
> TEXt?

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

BGM?

Group: CRT Readout Transfer

Purpose: Queries the 371A for the ß or gm/DIV readout.

Header	Argument	Definition and Syntax
BGM?		Respond with the ß or gm/DIV readout from the display
		Response syntax: **BGM** <para> where: <para> = <NR1>

REAdout?

Group: CRT Readout Transfer

Purpose: Queries the 371A for the vertical and horizontal cursor parameter readouts.

Header	Argument	Definition and Syntax
REAdout?	default **STR**ing **SCI**entific	The default argument is STRing. Window cursor values are for the location of the bright dot in the corner of the window cursor. The window cursor used depends on the last cursor mode setting made at the front panel. The response can be specified to be in either string or scientific notation format. If the cursor is offscreen, the returned values will be preceded by question marks and are not valid. Note also the commands for cursor positioning in the Cursor Commands and Queries group.

Response syntax:
READOUT <xread>, <yread>

where:

<xread> =   horizontal reading in volts

<yread> =   vertical reading in amperes (ohms or siemens for f line cursor)

When queried with the SCIentific argument, the responses <xread> and <yread> are <NR3>.

TEXt

Group:	CRT Readout Transfer

Purpose:	Allows the controller to write text on the 371A display.

Header	Argument	Definition and Syntax
TEXt	<string>	Display the text string in the text display area of the CRT graticule
		Command syntax: TEXt "<text>"
		where: <text> = a message with a length of no more than 24 characters.

TEXt?

Group: CRT Readout Transfer

Purpose: Queries the 371A for any text displayed in the text area of the CRT graticule.

Header	Argument	Definition and Syntax
TEXt?		Respond with the text currently displayed in the test area of the CRT.
		Although text may be stored in mass storage along with the settings, it can be sent over the bus with this query.
		Response syntax: TEXT "<text>"
		where: <text> = the message from the CRT text area, with no more than 24 characters.

Cursor Commands and Queries

The Cursor group selects Cursor mode and positions the selected cursor on the display, or queries the 371A on the position of the cursor.

The commands and queries in this group include:

CURSor
DOT
DOT?
LINe
LINe?
WINdow
WINDow?

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

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CURSor

Group: Cursor

Purpose: Sets the 371A mode to OFF.

Header	Argument	Definition and Syntax
CURSor	OFF	Set the cursor mode to OFF
		Command syntax: **CURSor OFF**
		Also see the REAdout? query in the CRT Readout Command group for extracting data values from the cursor.

DOT

Group:	Cursor	
Purpose:	Sets the 371A dot cursor position to a specific point on the currently displayed curve.	

Header	Argument	Definition and Syntax
DOT	\<NR1\>	Set the dot cursor on the specified data point in the current curve.
		Command syntax: DOT \<data\>
		where: \<data\> = 1 or 2 or 3 ... 1024 (0 is the beginning of the curve and 1024 is the end)

DOT?

Group: Cursor

Purpose: Queries the 371A for the location of the dot cursor on the currently displayed curve.

Header	Argument	Definition and Syntax
DOT?		Respond with the dot cursor position.
		Response syntax: DOT <NR1>
		where: <NR1> = a number between 0 and 1024 specifying the location of the dot cursor on the currently-displayed curve. (Zero is the beginning of the curve and 1024 is the end.)

LINe

Group: Cursor

Purpose: Sets the f line cursor intercept position on the display.

Header	Argument	Definition and Syntax
LINe	<NR1>, <NR1>	Sets the f line cursor intercept position. This position must be a point on a square grid whose bottom left corner coordinates are 0, 0 and top right corner coordinates are 1000, 1000.
		Command syntax: LINe <data1>,<data2>
		where: <data1> = 0 ... 1000 horizontal position <data2> = 0 ... 1000 vertical position

LINe?

Group: Cursor

Purpose: Queries the 371A for the intercept position of the f line cursor on the display.

Header	Argument	Definition and Syntax
LINe?		Respond with the f line cursor intercept position. This position is a point on a square grid whose bottom left corner coordinates are 0.0 and top right corner coordinates are 1000, 1000.
		Response syntax: **LINE <data1>,<data2>**
		where: <data1> = 0 . . . 1000 horizontal position <data2> = 0 . . . 1000 vertical position

WINdow

Group:	Cursor	
Purpose:	Positions and sizes the window cursor on the CRT graticule.	

Header	Argument	Definition and Syntax
WINdow	\<NR1\>, \<NR1\>, \<NR1\>, \<NR1\>	Set the window cursor to the specified position on the CRT graticule. (The cursor window is defined by four points, which are specified in the argument portion of the command.
		Command syntax: WINdow \<data1\>,\<data2\>,\<data3\>,\<data4\> where: \<data1\> = 0 . . . 1000 (bottom left horizontal position) \<data2\> = 0 . . . 1000 (bottom left vertical position) \<data3\> = 0 . . . 1000 (bottom right horizontal position) \<data4\> = 0 . . . 1000 (bottom right vertical position)

WINdow?

Group:	Cursor

Purpose: Queries the 371A for the position and size of the window cursor on the CRT graticule.

Header	Argument	Definition and Syntax
WINdow?		Respond with the window cursor position. (The cursor window is defined by four points, which are specified in the argument portion of the response.)

Response syntax:
WINDOW <data1>,<data2>,<data3>,<data4>

where:

<data1> = 0 . . . 1000 (bottom left horizontal position)

<data2> = 0 . . . 1000 (bottom left vertical position)

<data3> = 0 . . . 1000 (bottom right horizontal position)

<data4> = 0 . . . 1000 (bottom right vertical position)

Display Commands and Queries

The Display group of commands and queries controls and reports the status of the display. The 371A settings controlled by this group include: mode, polarity, source, sensitivity, and calibration mode. Also included in this group is a command to send store-mode displays to specified locations in mass storage.

The commands and queries in this group are:

DISplay
DISplay?
ENTer
HORiz
HORiz?
VERt
VERt?

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

DISplay

Group: Display

Purpose: Set and change the display mode, polarity, and calibration mode.

Header	Argument	Linked Argument	Definition and Syntax
DISplay	NSTore STOre		Select non-store mode Select store mode.
			Command syntax: DISplay \<mode\> Where: \<mode\> = NSTore or STOre
	VIEw:	\<NR1\>	Select view mode and display a curve from the specified location.
			Command syntax: DISplay \<mode\>:\<index\> where: \<mode\> = VIEw \<index\> = 1 ... 80 (memory index)
	REF:	ON OFF	Display reference curve Turns off the reference curve display.
			Command syntax: DISplay \<mode\>:\<status\> where: \<mode\> = REF \<status\> = ON or OFF
	INVert:	ON OFF	Set the display invert mode. Reset normal display mode.
			Command syntax: DISplay \<mode\>:\<status\> where: \<mode\> = INVert \<status\> = ON or OFF

DISplay (Cont.)

Header	Argument	Linked Argument	Definition and Syntax
	CAL:	ZERo OFF FULl	Set the CRT calibration mode.
			Command syntax: DISplay <mode>:<status> where: <mode> = CAL <status> = ZERo or OFF or FULl

DISplay?

Group: Display

Purpose: Queries the 371A for the current settings of display mode, polarity, and calibration mode.

Header	Argument	Definition and Syntax
DISplay?		Responds with the current display settings.
		Response syntax: DISPLAY <mode1>,<mode2>,<mode3>,<mode4> where: <mode1> = INVERT:OFF or INVERT:ON <mode2> = CAL:ZERO or CAL:OFF or CAL:FULL <mode3> = NSTORE or STORE or VIEW:<NR1> <mode4> = REF:OFF or REF:ON

ENTer

Group: Display

Purpose: Stores the display in mass storage

Header	Argument	Definition and Syntax
ENTer	<NR1>	Store the displayed curve data in the specified memory location. (This command is valid only in store or view mode.)
		Command syntax: ENTer <index>
		where: <index> = 1 ... 80 (memory location)

HORiz

Group: Display

Purpose: Sets the 371A horizontal display source and sensitivity.

Header	Argument	Linked Argument	Definition and Syntax
HORiz	STPgen: COLlect:	<NR3> <NR3>	Select the horizontal display source and sensitivity (volt/div).
			Command syntax: HORiz <source>:<volt> where: <source> = COLlect or STPgen When <source> is COLlect: <volt> may be: • 1.0E-1 to 5.0E+0 if peak power watts is set to 3 KW/300 W • 5.0E+1 to 5.0E+2 if peak power watts is set to 30 W/3W • 5.0E+0 to 5.0E+1 if peak power watts is set to 300 mW or 30 mW. When <source> is STPgen: <volt> may be 1.0E-1 to 5.0E+0.

HORiz?

Group: Display

Purpose: Queries the 371A for the current horizontal source and sensitivity settings.

Header	Argument	Definition and Syntax
HORiz?		Respond with horizontal display source and sensitivity.
		Response syntax: **HORIZ <source>:<volt>** where: **<source>** = **COLLECT** or **STPGEN** **<volt>** = sensitivity (volt/div) **<NR3>**

VERt

Group:	Display		
Purpose:	Sets the vertical sensitivity of the 371A.		

Header	Argument	Linked Argument	Definition and Syntax
VERt	COLlect:	<NR3>	Set vertical sensitivity (A/div).

The source, COLlect, is required as the argument.

Command syntax:
VERt COLlect:<amp>

where:

<amp> =	1.0E+0 to 5.0E+1 when peak power watts is 3 KW
<amp> =	500.0E-3 to 5.0E+0 when peak Power watts is 300 W
<amp> =	1.0E-4 to 5.0E-3 when peak power watts is 30 W
<amp> =	1.0E-5 to 5.0E-4 when peak power watts is 3 W or 300 mW
<amp> =	1.0E-6 to 5.0E-5 when peak power watts is 30 mW

VERt?

Group: Display

Purpose: Queries the 371A for the vertical sensitivity settings.

Header	Argument	Definition and Syntax
VERt?		Respond with the vertical display source and sensitivity. COLLECT is always given as the source in the argument portion of the query.
		Response syntax: VERT COLlect:<amp> where: <amp> = sensitivity (A/div)

Instrument Parameter Commands and Queries

The Instrument Parameter commands and queries group is helpful for determining the status of the 371A when problems are encountered. The 371A can be queried for its firmware version, all current settings, a list of all valid command and query headers, and whether debug mode is enabled. A command is included in this group to place the 371A into a known operating condition by initializing most front-panel settings.

For active troubleshooting, the 371A can be placed in debug mode to display the last 15 characters of a received string. A test routine is available to report back ROM and RAM problems.

The commands and queries in this group are:

DEBug
DEBug?
HELp?
ID?
INIt
SET?
TESt?

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

DEBug

Group:	Instrument Parameter
Purpose:	Sets the debug mode

Header	Argument	Definition and Syntax
DEBug	ON OFF	Enable or disable the debug feature When ON, the 371A momentarily displays the last 15 characters of the received string in the error message area of the display. Command syntax: DEBug \<status> where: \<status> = ON or OFF

DEBug?

Group: Instrument Parameter

Purpose: Queries the 371A for the status of the debug mode.

Header	Argument	Definition and Syntax
DEBug?		Respond with the status of the debug mode.
		Response syntax: **DEBUG <status>**
		where **<status> =** ON or OFF

HELp?

Group: Instrument Parameter

Purpose: Asks the 371A for a list of all valid command and query headers.

Header	Argument	Definition and Syntax
HELp?		Respond with a list of all valid command and query headers.
		Response syntax: HELP READOUT, TEXT, LINE, DOT, WINDOW, CURSOR, BGM, DISPLAY, HORIZ, VERT, STPGEN, MEASURE, ENTER, RECALL, SAVE, PLOT, PSTATUS, PKPOWER, CSPOL, CSOUT, VCSPPLY, OUTPUTS, WFMPRE, CURVE, WAVFRM, RQS, OPC, EVENT, TEST, INIT, ID, DEBUG, SET

ID?

Group: Instrument Parameter

Purpose: Queries the 371A for its firmware version.

Header	Argument	Definition and Syntax
ID?		Respond with the 371A ID
		Response syntax: **ID SONY_TEK/371A,V81.1F\<version\>** where: **\<version\>** = current firmware version

INIt

Group:	Instrument Parameter
Purpose:	Initializes the 371A to its power-up settings.

Header	Argument	Definition and Syntax
INIt		Initialize the instrument. Settings are the same as at power-up and are shown below.

Function	INIt Value
DISplay	STORE
CURSor	OFF
DISplay CAL:	OFF
DISplay INV:	OFF
DISplay REF:	OFF
STP CUR:	1.0E-3
STP OFF:	0.00
STP INV:	OFF
PKPower	300
CSPol	NPN
HORiz COL:	1.0E+0
OPC	OFF
MEAsure	REPEAT
STP NUM:	2
STP MUL:	OFF
VCSpply	0.0
VERt COL:	1.0E+0
RQS	On
DEBug	OFF

SET?

Group:	Instrument Parameter	
Purpose:	Queries the 371A for its current front-panel settings.	

Header	Argument	Definition and Syntax
SET?		Respond with the front-panel settings.
		Response syntax: OPC <mode>;RQS <mode>;PKPOWER <watts>; CSPOL ,<polarity>;HORIZ <source:size>; VERT COLLECT:<size>;STPGEN OUT:<mode>, NUMBER:<number>,OFFSET:<offset>,INVERT:<mode>, MULT:<mode>,<source:size>;VCSPPLY <percent>; MEASURE <mode>;DISPLAY INVERT:<mode>; CAL:<mode>,<display mode>,REF:<mode>, TEXT "<text>"; CURSOR <mode>
		Response syntax [when the measurement mode is SWEep or SSWeep (slow sweep)]: OPC <mode>;RQS <mode>;PKPOWER <watts>; CSPOL ,<polarity>;HORIZ <source:size>; VERT COLLECT:<size>;STPGEN OUT:<mode>, NUMBER:<number>,OFFSET:<offset>,INVERT:<mode>, MULT:<mode>,<source:size>;VCSPPLY <percent>; DISPLAY INVERT:<mode>;CAL:<mode>,<display mode>,REF:<mode>,MEASURE SWEEP;TEXT "<text>"; CURSOR <mode>

TESt?

Group:	Instrument Parameter	
Purpose:	Performs tests on the ROM and RAM	

Header	Argument	Definition and Syntax
TESt?		Perform ROM and RAM checks and respond with the result.
		Response example (with no error found): **TEST ROM:0000,RAM:0000**
		NOTE
		Refer to "GPIB Diagnostics" in Chapter 3: Maintenance of the 371A Service manual for codes other than 0000.

Miscellaneous Commands and Queries

The Miscellaneous commands and queries group contains queries for the status of the output connectors, measurement mode, and plotter, as well as commands to set the measurement mode, start the plotter, and save and recall sets of front-panel settings.

The commands and queries in this group are:

MEAsure
MEAsure?
OUTputs?
PLOt
PSTatus?
RECall
SAVe

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

MEAsure

Group:	Miscellaneous	
Purpose:	Selects the measurement mode.	

Header	Argument	Definition and Syntax
MEAsure	REPeat SINgle SWEep SWEeep	Select the measurement mode.
		Command syntax: MEAsure \<mode> where: \<mode> = REPeat or SINgle or SWEep or SSWeep

MEAsure?

Group: Miscellaneous

Purpose: Queries the 371A for the current measurement mode setting.

Header	Argument	Definition and Syntax
MEAsure?		Respond with the current measurement mode setting.
		Response syntax: MEASURE <mode> where: <mode> = REPEAT or SINGLE or SWEEP or SSWEEP

OUTput?

Group: Miscellaneous

Purpose: Queries the 371A for the status of the output connectors.

Header	Argument	Definition and Syntax
OUTputs?		Respond with the status of the output connectors.

Response syntax:
OUTPUTS <status>

where:
<status> =	**ENABLED** or **DISABLED**
and	
ENABLED =	all connector outputs enabled except interlock
DISABLED =	all connector outputs disabled, except interlock

PLOt

Group:	Miscellaneous	
Purpose:	Defines which data will be plotted and starts the plot process.	

Header	Argument	Definition and Syntax
PLOt	ALL CURve	Select the plotter interface mode, curve only or curve plus readout and graticule, and start the output to the plotter
		Command syntax: PLOt <mode> where: <mode> = ALL or CURve and ALL = Curve with readout data and graticule CUR = Curve only

PSTatus?

Group: Miscellaneous

Purpose: Queries the 371A for the status of the plotter interface.

Header	Argument	Definition and Syntax
PSTatus?		Respond with the current status of the plotter.
		Response syntax: **PSTATUS <status>** where: <status> = **READY or BUSY** and **READY =** idle mode **BUSY =** busy mode

RECall

Group: Miscellaneous

Purpose: Recalls a set of front-panel settings.

Header	Argument	Definition and Syntax
RECall	<NR1>	Recall the front-panel settings from a specified memory location.
		Command syntax: RECall<index> where: <index> = 1 ... 80 (memory location)

SAVe

Group:	Miscellaneous	
Purpose:	Saves the current set of front-panel settings.	

Header	Argument	Definition and Syntax
SAVe	<NR1>	Save the current front-panel settings in the specified memory location
		Command syntax: SAVe <index> where: <index> = 1 . . . 80 (memory location)

Status and Event Commands and Queries

The Status and Event Reporting group sets and reports the status of service requests and operation complete service requests. A query is also included for the event code of the latest event.

The commands and queries in this group are:

EVEnt?
OPC
OPC?
RQS
RQS?

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

EVEnt?

Group: Status and Event

Purpose: Queries the 371A for the event code of the most recent event.

Header	Argument	Definition and Syntax
EVEnt?		Return the event code for the most recent event.
		Response syntax: **EVENT \<code\>** where: \<code\> = A three-digit event code. Refer to "Event Codes," later in this chapter for a list of event codes and definitions.

OPC

Group: Status and Event

Purpose: Sets the status of operation complete service request.

Header	Argument	Definition and Syntax
OPC	ON OFF	Enable or disable assertion of operation complete service request upon completion of an operation, a change in the circuit breaker status, or a change in the status of the interlock system.
		Command syntax: OPC \<status\>
		where: \<status\> = ON or OFF

OPC?

Group:	Status and Event

Purpose: Queries the 371A for the status of the operation complete service request (OPC).

Header	Argument	Definition and Syntax
OPC?		Respond with the current status of the operation complete service request feature.
		Response syntax: OPC <status> where: <status> = ON for enabled or OFF for disabled

RQS

Group: Status and Event

Purpose: Sets the status of Service Requests.

Header	Argument	Definition and Syntax
RQS	ON OFF	Enabled or disable assertion of service requests (SRQs).
		Command syntax: RQS \<status\>
		where: \<status\> = ON or OFF

RQS?

Group: Status and Event

Purpose: Queries the 371A for the status of service request.

Header	Argument	Definition and Syntax
RQS?		Respond with the current status of service request.
		Response syntax: **RQS? <status>** where: **<status> =** ON for enabled or OFF for disabled

Step Generator Command and Query

The Step Generator command and query group sets and asks for the status of the step generator settings.

The Step Generator group has one command and one query:

STPgen
STPgen?

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

STPgen

Group:	Step Generator	
Purpose:	Sets the step generator source, step size, number of steps, polarity, step multiplication, and offset>	

Header	Argument	Linked Argument	Definition and Syntax
STPgen	OUT:	ON OFF	Enable or disable the step generator output.
			Command syntax: STPgen OUT:\<mode\> where: \<mode\> = ON or OFF
	CURrent: VOLtage:	\<NR3\> \<NR3\>	Set the step generator to provide current or voltage steps, and set the step size in amperes or volts.
			Command syntax: STPgen \<source\>:\<val\> where: \<source\> = CUR or VOL \<val\> = 1.0E-6 through 2.0E-3 when Peak Power Watts is 30 W/3 W/0.3 W/0.03W and 1.0E-3 to 2.0E+0 when Peak Power Watts is 3 KW/300 W for current step size (amp/div). \<val\> = 2.0E-1 through 5.0E+0 in an 1–2–5 sequence for voltage step size (volt/step). Example: STPgen CURrent:1.0E-3

(continued on next page)

STPgen (cont.)

Header	Argument	Linked Argument	Definition and Syntax
	NUMber	\<NR1\>	Set the number of steps to be generated
			Command syntax: STPgen NUMber:\<val\>
			where: \<val\> = 0, 1, 2, . . . 10 (0 through 5 when Step/Offset Amplitude is 5 V or 2A).
	INVert:	ON OFF	Set the step generator polarity\>
			Command syntax: STPgen INVert:\<mode\> where: \<mode\> = ON or OFF
	MULt	ON OFF	Set the step generator step multi 0.1X mode.
			Command syntax: STPgen MULt:\<mode\> where: \<mode\> = ON or OFF
	OFFset:	\<NR2\>	Set the offset of the step generator.
			Command syntax: STPgen OFFset:\<val\>
			where: \<val\> = 0.00 or 0.01 . . . 9.99 or 10.00 (0.00 through 5.00 when Step/Offset Amplitude is 5 V or 2 A)

STPgen?

Group: Step Generator

Purpose: Queries the 371A for the current settings of the step generator source, number of steps, step size, polarity, step multiplication, and offset.

Header	Argument	Definition and Syntax
STPgen?		Respond with the step generator source, amps/step or volt/step, number of steps, offset, polarity, multiplier mode, or output mode.
		Response syntax: STPGEN:\<output\>,NUMBER:\<num\>,OFFSET:\<offset\>, INVERT:\<invert\>,MULT:\<mult\>,\<typ:size\>
		where: \<output\> = ON or OFF
		\<num\> = number of steps, 0 – 10
		\<offset\> = offset value multiplier
		\<invert\> = invert mode status, ON or OFF
		\<mult\> = step multi status, ON or OFF
		\<type:size\> = CURRENT:size (A/step) or VOLTAGE:size (V/step)

Waveform Transfer Commands and Queries

The Waveform Transfer group allows curve or preamble data (or both) to be stored in, or recalled from, mass storage. There is also a command to set the number of curve data points stored and a related query to determine the length of a previously defined waveform.

The commands and queries in this group are:

> CURve
> CURve?
> WAVfrm?
> WFMpre
> WFMpre?
> WFMpre NR.PT
> WFMpre? NR.PT

An alphabetical listing of all command and query headers is given in the "Command Index."

A cross reference for front-panel controls and corresponding GPIB commands and queries is also given in Table 5-6.

CURve

Group:	Waveform Transfer	
Purpose:	Store a curve.	

Header	Argument	Definition and Syntax
CURve	\<string\>	Load the curve into the specified memory location.
		Command syntax: **CURve \<string\>**
		where: \<string\> = CURVID:\<curveid\>,%\<binary data\>
		Where: \<curveid\> = "INDEX \<index\>"
		\<binary data\> = \<count\>\<firstpoint\> . . . \<last point\> \<checksum\>
		where: \<index\>= 1 . . . 80 for memory storage location.
		\<count\> = two bytes indicating the number of data points plus one.
		\<point\> = two bytes indicating the X coordinate and two bytes indicating the Y coordinate for a point (00 through FF).
		\<checksum\> One byte, the two's complement of the modulo-256 sum of the preceding binary data.

CURve?

Group: Waveform Transfer

Purpose: Queries the 371A for curve data.

Header	Argument	Definition and Syntax
CURve?		Respond with the curve data for the view curve when in view mode, and with the curve data for the current display when in store mode.
		Response syntax: **CURVE CURVID <curvid>,%<binary data>**
		Where: <curveid> = "INDEX <index>"
		<binary data> = <count><firstpoint> ... <last point> <checksum>
		where: <index>= 1 ... 80 for memory storage location.
		<count> = two bytes indicating the number of data points plus one.
		<point> = two bytes indicating the X coordinate and two bytes indicating the Y coordinate for a point (00 through FF).
		<checksum> One byte, the two's complement of the modulo-256 sum of the preceding binary data.

WAVfrm?

Group:	Waveform Transfer	
Purpose:	Queries the 371A for the curve and preamble data. This query functions as a combination of the WFMpre? and CURve? queries.	

Header	Argument	Definition and Syntax
WAVfrm?		Respond with both preamble and curve data for the current waveform.
		See the discussions for WFMpre? and CURve? for details.
		The preamble and curve data are separated by a semicolon.

WFMpre

Group: Waveform Transfer

Purpose: Stores the preamble data for the currently displayed waveform into a specified memory location.

Header	Argument	Definition and Syntax
WFMpre	<string>	Load the waveform preamble into the location indicated by the current content of the memory index display.

Command syntax:
WMFpre <string>

where:>
<string> = WFD:<wfid>,ENCDG:BIN,NR.PT:<point>, PT.FMT:XY,XMULT:<x multi>,XZERO:0,XO FF:<x off>,XUNIT:V,YMULT:<y multi>, YZERO:0YOFF:<y off>,YUNIT:A,BYT/NR:2, BN.FMT:RP,BIT/NR:10,CRVCHK: CHKSMO,LN.FMT:<format>

where:
<wfid> = "INDEX <num>/VERT <amp>/HORIZ <volt>/STEP <step>OFFSET <offset>/BGM <para>/VCE <percent>/TEXT <txt>/ HSNS <mode>"

where:
<num> = display address: 0 for CRT, 1 . . . 80 for memory location , <NR1>

<amp> = sensitivity, A/div <NR3>

<volt> = sensitivity, V/div <NR3>

<step> = step amplitude, V or A/step <NR3>

<offset> = step offset, V or A

<para> = ß or gm

<percent> = collector supply VARIABLE setting , %

<txt> = readout of text area

WFMpre (cont.)

Header	Argument	Definition and Syntax
	<mode> =	horizontal source, V_{CE} or V_{BE}
	<point> =	number of points in the curve (1 thru 1024)
	<x multi> =	horizontal scale factor, <NR3>
	<x off> =	horizontal offset, <NR1>
	<y multi> =	vertical scale factor, <NR3>
	<y off> =	vertical offset, <NR1>
	<format> =	VECTOR, DOT, or SWEEP <cnt>

WFMpre?

Group:	Waveform Transfer	
Purpose:	Queries the 371A for the preamble data stored in a specified memory location.	

Header	Argument	Definition and Syntax
WFMpre?		Respond with the waveform preamble from the specified memory location.

Response syntax:
WFD:<wfid>,ENCDG:BIN,NR.PT:<point>,PT.FMT:XY,
XMULT:<x multi>,XZERO:0,XOFF:<x off>,XUNIT:V,
YMULT:<y multi>,YZERO:0,YOFF:<y off>,YUNIT:
A,BYT/NR:2,BN.FMT:RP,BIT/NR:10,CRVCHK:CHKSMO,
LN.FMT:<format>

where:

<wfid> = "INDEX <num>/VERT <amp>/HORIZ <volt>/STEP <step>OFFSET <offset>/BGM <para>/VCE <percent>/TEXT <txt>/ HSNS <mode>"

where:

<num> =	display address: 0 for CRT, 1 . . . 80 for memory location , <NR1>
<amp> =	sensitivity, A/div <NR3>
<volt> =	sensitivity, V/div <NR3>
<step> =	step amplitude, V or A/step <NR3>
<offset> =	step offset, V or A
<para> =	ß or gm
<percent> =	collector supply VARIABLE setting , %
<txt> =	readout of text area
<mode> =	horizontal source, V_{CE} or V_{BE}
<point> =	number of points in the curve (1 thru 1024)
<x multi> =	horizontal scale factor, <NR3>

WFMpre? (cont.)

Header	Argument	Definition and Syntax	
		<x off> =	horizontal offset, <NR1>
		<y multi> =	vertical scale factor, <NR3>
		<y off> =	vertical offset, <NR1>
		<format> =	VECTOR, DOT, or SWEEP <cnt>

WRMpre NR.PT

Group: Waveform Transfer

Purpose: Sets the length of the waveform

Header	Argument	Linked Argument	Definition and Syntax
WFMpre	NR.PT:	<NR1>	Set the number of points input for the **CUR**ve command.
			Command syntax: **WFMpre NR.PT:<points>** where: <points> = 1 ... 1024

WFMpre? NR.PT

Group: Waveform Transfer

Purpose: Queries the 371A for the length of a waveform previously defined with the
WFMpre NR.PT command.

Header	Argument	Definition and Syntax
WFMpre?	NR.PT:	Respond with the **NR.PT** waveform preamble data.
		Response syntax: **WFMPRE NR.PT:**<points> where: <points> = 1 ... 1024

SERVICE REQUESTS

The standard GPIB status and error reporting system used by the 371A sends interrupt messages to the bus controller by asserting the service request (SRQ) line on the bus. This SRQ message indicates that either an error or a change in status has occurred.

Handling Service Requests

To service an interrupt, the controller polls the instruments on the bus. The instrument asserting SRQ (the 371A in this case) returns a status byte indicating the category of the event causing the service request. Each service request is automatically cleared after responding to the poll. If there is more than one event to report, the instrument reasserts SRQ until all pending events have been reported. (A complete list of status bytes that can occur is found in Table 5-9.)

After polling the 371A for the status byte, the controller can obtain more detailed information about the service request event by sending the EVEnt? query. The response to an EVEnt? query is an event code, which is an <NR1> number corresponding to certain conditions that may have occurred. Table 5-10 lists the event codes returned by the 371A.

The status byte and event code can be accessed later if they are not read and cleared immediately. In the case of multiple events, only the latest status byte and the one pending are saved. Event codes, however, are kept in a 10-deep, Last-In-First-Out (LIFO) buffer for later recall.

The following program segments demonstrate how service requests are handled along with the corresponding status byte and event code. The status byte and event code are printed on the controller display to track instrument status.

IBM PC: (This is for use with the auto-serial-poll flag disabled in the National instruments GPIB card configuration file.)

```
800 REM *** SIMPLE SRQ HANDLER FOR 371A ***
810 CALL IBRSP(BD%,SPR%)
820 WRT$="EVENT?"
830 CALL IBWRT(BD%,WRT$
840 RD$=SPACE$(100)
850 CALL IBRD(BD%,RD$)
860 PRINT "STATUS=";SPR%,"EVENT=";RD$
```

Hewlett Packard 200/300 Series:

```
800 REM *** SIMPLE SRQ HANDLER FOR 371A ***
810 STB=SPOLL(DEV)                          ! Poll device
                                              previously
                                              defined.
820 OUTPUT DEV;"EVENT?",END                 ! Send "EVENT?"
                                              query.
830 ENTER DEV;EVENT$                        ! Input response.
840 PRINT "STATUS=";STB;" EVENT= ";EVENT$
                                            ! Show status and
                                              event.
```

Masking Service Requests

The operation complete service request (OPC SRQ) is a special type of service request to communicate that certain instrument processes have been finished. These OPC service requests indicate that the 371A has finished one operation and is ready to proceed to the next.

It may not always be desirable to interrupt the program with service request or OPC service requests. Either type of service request can be masked so that the 371A will not assert them until the mask is removed. This masking is accomplished with the **RQS** and **OPC** commands.

RQS ON enables the 371A to assert an SRQ when it has an event to report. If this feature is turned off (**RQS OFF**), up to 10 events are still accumulated and can be retrieved with successive EVEnt? queries.

OPC ON enables the 371A to assert an **OPC SRQ** upon completion of an operation, a change in circuit breaker status, or a change in the status of the interlock system.

NOTE

The response to RQS? and OPC? queries only indicates whether the function is enable (ON) or disable (OFF). They do not give any status or event information.

Status Bytes

Table 5-9 lists the status byte response.

Table 5-9
Status Byte Responses

8	7	6	5	4	3	2	1	Decimal	Condition
0	0	0	0	0	0	0	0	0	*No status to report.* This status byte is set when there are no events or device-dependent events to report.
0	1	0	0	0	0	0	1	65	*Power on.* This occurs when the power is turned on, after having been off.
0	1	0	0	0	0	1	1	67	*User request.* This status byte occurs when the front-panel RQS key is pressed.
0	1	1	0	0	0	0	1	97	*Command error.* This status byte is set when a message cannot be parsed or recognized.
0	1	1	0	0	0	1	0	98	*Execution error.* This status byte is set when a message is parsed and is recognized, but cannot be executed. For example, if the floppy disk is not in place when a SAVE 20 command is received, the 371A registers an execution error.
0	1	1	0	0	0	1	1	99	*Internal error.* This status byte indicates that the 371A microcomputer has discovered a malfunction that could cause the instrument to operate incorrectly.
1	1	0	0	0	0	0	0	192	*Device-dependent events.* This status byte is set when there is an event specific to the 371A. Primarily, these events signify the completion of a process, such as "PLOTTER OUTPUT COMPLETE".

NOTES: Bits 1 through 4 are the four-bit status code

Bit 6   high (1) indicates abnormal condition
low (0) indicates normal condition

Bit 7 indicates SRQ asserted (depends on RQS command)

Event Codes

Table 5-10 describes the meaning of the status bytes and event codes.

Table 5-10
Status Bytes and Event Codes

Status Byte	Event Code	Meaning
SYSTEM EVENTS		
0	0	No error
65	401	Power on
67	403	User request (RQS key)
COMMAND ERRORS		
97	101	Command header error
97	102	Command argument count error
97	103	Command argument error
97	106	Command syntax error
97	108	Waveform checksum error
97	109	Byte count error
EXECUTION ERRORS		
98	201	Command not executable in local mode
98	203	Output buffer overflow; remaining output lost
98	204	Setting conflicts
98	205	Argument out of range
98	272	Collector Supply breaker unmatch
98	273	NR.PT byte count mismatch
98	274	No waveform available
98	275	Step Generator disabled
98	276	Disk format error
98	277	Non-volatile memory data empty
98	278	Non-volatile memory read/write error
98	279	Checksum error
98	280	Disk data empty
98	281	Disk not ready
98	282	Disk write-protected
98	283	Disk full
98	284	Invalid data
98	285	Disk fault
98	286	Disk read error
98	287	Disk write error
98	288	Disk seek error
INTERNAL ERRORS		
99	353	Phase-lock system failed
99	354	Collector supply is overheated
99	355	Series resistor is overheated
99	357	Collector supply fuse blown

(continued on next page)

Table 5-10 (cont.)
Status Bytes and Event Codes

Status Byte	Event Code	Meaning
DEVICE DEPENDENT EVENTS		
192	750	Operation complete
192	751	Sweep measurement operation complete
192	752	Plotter output complete
192	753	Collector Supply recovered
192	754	Collector Supply breaker changed
192	755	Interlock system changed
192	756	Disk format complete
192	757	Data copy complete
192	758	Non-volatile memory erase complete

Appendix A
SPECIFICATIONS

This appendix specifies the electrical, mechanical, and environment performance requirements of the 371A.

PERFORMANCE CONDITIONS

The following electrical and environmental characteristics are valid for instruments operated at an ambient temperature from +10° C to +40° C, after an initial warm-up period of 20 minutes, and when previously calibrated at a temperature from +15° C to +25° C.

The performance of all stimulus outputs (collector high current, collector high voltage, step generator current, step generator voltage) should be verified on the test fixture unit.

Table A-1
Collector Supply Electrical Specification

Characteristic	Performance Requirement	Supplemental Information
Collector supply polarity		Selected by the collector supply POLARITY button.
NPN+	Positive pulse for 300 W/3 kW peak power watts Positive rectified sine-square wave for 30 W/3 W/300 mW/30 mW peak power watts.	
PNP-	Negative pulse for 300 W/3kW peak power watts Negative rectified sine-squared wave for 30 W/3 W/300 mW/30 mW	
Peak power watts range	3 kW 300 W 30 W 3 W 300 mW 30 mW	Selected by the PEAK POWER WATTS buttons, but 300 mW or 30 mW setting is selected by the 30 W or 3 W button with the SHIFT button. Derived from nominal peak open circuit collector voltages and nominal series resistance value.
Collector peak current		With a shorted load in the test fixture unit.
3 kW range	400 A	Pulsed collector supply
300 W range	40 A	Pulsed collector supply
30 W range	40 mA, -20%, +20%	Sine wave collector supply
3 W/300 mW range	4 mA, -20%, +20%	Sine wave collector supply
30 mW range	0.4 mA, -20%, +20%	Sine wave collector supply
Maximum peak voltage	Peak open circuit voltage	At 100% collector supply VARIABLE
3 kW range	30 V, +10%, -5%	Pulsed collector supply
300 kW range	30 V, +10%, -5%	Pulsed collector supply
300 W range	30 V, +10%, -5%	Pulsed collector supply
30 W range	3 kV, +10%, -0%	Rectified sine-squared wave collector supply
3 W range	3 kV, +10%,-0%	Rectified sine-squared wave collector supply
300 mW range	300 V, 15%, -0%	Rectified sine-squared wave collector supply
30 mW range	300 V, +15%, 0%	Rectified sine-squared wave collector supply

(table continued on next page)

Table A-1 (cont.)
Collector Supply Electrical Specification

Characteristics	Performance Requirement	Supplemental Information
Collector supply variable	0 to 100.0%	% of maximum peak voltage value is displayed in the CRT readout area. Provides uncalibrated variable control of the collector supply amplitude from 0 to 100% in 0.1% increments.
Looping compensation	Valid for high-voltage mode	Cancels stray capacitance between the collector terminal and ground at collector supply PEAK POWER WATTS 30 w/3 W/300 mW/30 mW
Sweep start voltage	Less than +10%, -10% of peak volt	Valid for high voltage mode
OUTPUTS indicator		Lights when all outputs (collector supply and step generator output terminals) are enabled.
Pulsed collector supply	Pulse amplitude is controlled by the collector supply VARIABLE	Available in high current mode (PEAK POWER WATTS 3 KW/300 W)
Repetition rate	One-fourth (X.25) line frequency	at 3 KW peak power watts
	One-half (X.5) line frequency	At 300 W peak power watts
Pulse width (half amplitude)	250 µs +10%, -10%	More than 30 % of the collector supply VARIABLE at open circuit
	150 µs to 250 µs	5% to 30% of the collector supply VARIABLE at open circuit
Rise time/fall time	40 µs to 120 µs	With collector supply VARIABLE at 50%
Overshoot/undershoot	Less than 5% of the total output	More than 5% of the collector supply VARIABLE at open circuit

Table A-2
Step Generator Supply Electrical Specification

Characteristics	Performance Requirement	Supplemental Information
Incremental accuracy (current or voltage steps, including offset)	Within 2% between any two steps	Without STEP MULTI .1X enabled
	Within 5% between any two steps	With STEP MULTI .1X enabled
Absolute accuracy (current or voltage steps, including offset)	Within 2% of total output +3% of STEP/OFFSET AMPLITUDE +10 nA or 2 mV.	Without STEP MULTI .X enabled
	Within 4% of total output +5% of STEP/OFFSET AMPLITUDE setting +10nA or 2 mV.	With STEP MULTI .1X enabled
Offset control range	Variable, 0 to 10 times STEP/OFFSET AMPLITUDE setting. However, 0 to 5 times when STEP/OFFSET AMPLITUDE is 5 V or 2 A.	Same polarity as step signal. Control resolution is 1%.
Number of steps	0 to 10. However, 0 to 5 when STEP/OFFSET AMPLITUDE setting is 5 V or 2 A	
Step polarity	Positive or Negative	Corresponds to the collector supply POLARITY when step generator INVERT is disabled.
Step rate	One-fourth (X.25) the line frequency	At 3 KW peak power watts.
	One-half (X.5) the line frequency	At 300 W peak power watts
	Twice (X2) the line frequency	At 30 W.3 W/300 mW/ 30 mW peak power watts
Current mode		Provides current staircase or pulsed current step.
Amplitude range		Selected by STEP/OFFSET AMPLITUDE button
Normal step	1 μA to 2 mA in a 1-2-5 sequence	Collector supply high-voltage mode (30 W/3 W/ 300 mW/30 mW)
Pulsed step	1 mA to 2 A in a 1-2-5 sequence	Collector supply high-current mode (3 KW /300 W)
Maximum current	20 times step amplitude, except 10 times STEP/OFFSET AMPLITUDE when control is set to 2 A per step.	
Maximum voltage	10 V, +20%, -20%	
Ripple plus noise	Less than 1% of the step amplitude +10 nA.	Checked with an oscilloscope with 20 MHz bandwidth.

(table continued on next page)

Table A-2 (cont.)
Step Generator Supply Electrical Specification

Characteristics	Performance Requirement	Supplemental Information
Pulsed current steps		When pulsed collector supply (peak power watts 3 KW/300 W) is selected, the step current automatically becomes pulsed.
Pulse width	500 µs, +10%, -10%	With 1-kΩ load, 1-mA/step
Rise time (see NOTE)	Less than 40 µs	With 1-kΩ load, 1-mA/step
Fall time (see NOTE)	Less than 40 µs	With 1-kΩ load, 1-mA/step
Overshoot/undershoot	Less than 10%	With 1-kΩ load, 1-mA/step and zero collector supply VARIABLE.
Voltage mode		Provides a voltage staircase step
Step amplitude range	200 mV to 5 V in a 1-2-5 sequence	Selected by STEP/OFFSET AMPLITUDE control.
Short circuit current limiting	100 mA +50%, -20%	
Maximum voltage	20 times step amplitude except 10 times when STEP AMPLITUDE control is set to 5 V/step.	
Ripple plus noise	Within 1 % of the step amplitude +10 mV	Check with an oscilloscope with 20 MHZ bandwidth.

NOTE: Degradation occurs when the DUT resistance (Rdut) is X10 greater than the current sense resistor (Rsense) of the amplifier.

The time constants for the rise and fall time is Tdut = TO (1 + Rdut/Rsense): where Tdut is the time constant for the DUT with Rdut resistance, and TO is the time contstant for the DUT with zero resistance.

The following lists the current sense resistors and their corresponding STEP AMPLITUDE setting (with STEP MULTI .1X on)

Rsense	STEP AMPLITUDE (with STEP MULTI .1X on) Setting
0.1 Ω	2 A and 1 A STEP (200 mA and 100 mA STEP)
1.0 Ω	500, 200, and 100 mA STEP (50, 20, and 10 mA STEP)
10 Ω	50, 20, and 10 mA STEP (5, 2, and 1 mA STEP)
100 Ω	5, 2, and 1 mA STEP (500, 200, and 100 µ A STEP)
1.0 kΩ	500, 200, and 100 µA STEP (50, 20,, and 10 µA STEP)
10 kΩ	50, 20, and 10 µA STEP (5, 2, and 1 µA STEP)
100 kΩ	5, 2, and 1 µA STEP (500, 200, and 100 nA STEP)

Table A-3
Vertical Deflection System Electrical Specification

Characteristics	Performance Requirement	Supplemental Information
Collector current (I_C) range	1 A/DIV to 50 A/DIV	With PEAK POWER WATTS set to 3 kW
	500 mA/DIV to 5 A/DIV	With PEAK POWER WATTS set to 300 W
	100 µA/DIV to 5 mA/DIV	With PEAK POWER WATTS set to 30 W
	10 µA/DIV to 500 µA/DIV	With PEAK POWER WATTS set to 3 W/300 mW
	1 µA/DIV to 50 µA/DIV	With PEAK POWER WATTS set to 30 mW
Collector current (I_C) accuracy	Within 0.1 division of the vertical graticule lines.	
Collector current (I_C) cursor accuracy	Within 1.5% of the readout +0.1 division of the CURRENT/DIV setting.	In store mode (use the dot cursor).

Table A-4
Horizontal Deflection System Electrical Specification

Characteristics	Performance Requirement	Supplemental Information
Collector supply range	Volts (V_{CE}): 100 mV/DIV to 5 V/DIV in a 1-2-5 sequence.	With peak power watts set to 3 kW/300 W
	50 V/DIV to 500 V/DIV in a 1-2-5 sequence.	With peak power watts set to 30 W/3W
	5 V/DIV to 50 V/DIV in a 1-2-5 sequence.	With peak power watts set to 300 mW/30 mW
Step generator volts (V_{BE}) range	100 mV/DIV to 5 V/DIV in a 1-2-5 sequence.	
Step generator volts (V_{BE}) accuracy	Within 0.1 division	
Step generator volts (V_{BE}) cursor accuracy	Within 1.5% of the readout +0.1 division of the HORIZONTAL VOLTS/DIV setting	Check using the dot cursor.
	At 100 mV/DIV COLLECTOR: Within 5% of the readout +0.2 division of the HORIZONTAL VOLTS/DIV setting.	

Table A-5
CRT and Text Display Electrical Specification

Characteristics	Performance Requirement	Supplemental Information
CRT		
Type	Electrostatic deflection	
Phosphor	P31	
Screen Size	7 inch diagonal, internal graticule and scale factor	
Orthogonality	90 degrees, within 0.6 degrees	
Trace rotation	At least ± 3 degrees	
Geometry	0.5 minor division or less of tilt or bowing	
	0.75 minor division or less of keystone effect.	
Text display		
Alphanumeric Character set (1)	ASCII character set except double quote (") (the lower-case u is recognized as µ.	GPIB-accessible with the TEXt (GPIB) command
Alphanumeric Character set (2)	space, A, B. . . Z, space, m, µ, n,q, . 0, 1 . . . 9, -, /, *, (,), =	Accessible with the cursor position buttons (up, down, left, right).
Maximum text string length	24 characteristics	
Character size	About 3 mm height, 2 mm width.	

Table A-6
Power Source Electrical Specification

Characteristic	Performance Requirement		
Nominal Line Voltage Ranges	Range	Main Fuse	Collector Fuse
240 V	216 V - 250 V	250 V, 1 A, slow blow	250 V, 2 A, slow blow
200 V	180 V - 220 V		
120 V	108 V - 132 V	250 V, 2A, slow blow	250 V, 4 A, slow blow
100 V	90 V - 110 V		
Line Frequency	48 Hz - 63 Hz		
Maximum Power	400 W, 4.5 A		

Table A-7
Mechanical Specification

Characteristic	Specification
Weight	Approximately 79.3 lb (36 kg)
Height	Approximately 13.1 in (333 mm)
	With feet and handles removed: approximately 16.9 in (429 mm)
Width	Approximately 16.9 in (429 mm)
Depth	Approximately 24.1 in (638 mm)

Table A-8
Environmental Specification

Characteristic	Performance Requirement
Temperature	
Operating	+10° C to +40° C
Storage	-22° to +60° C
Transportation	-40° C to +65° C
Temperature gradient	
Operating	≤ 15° C per hour (no condensation)
Storage and Transportation	≤ 30° C per hour (no condensation)
Altitude	
Non-operating	To 50,000 feet
Operating	To 15,000 feet
	Maximum operating temperature decreases 1° C each 1,000 feet above 5,000 feet.
Humidity	
Non-operating/operating	MIL-T-28800D paragraph 4.5.5.1.1.2 (5 days humidity with temperature cycling)
Relative humidity	
Operating	20% to 80% (no condensation)
Storage	10% to 90% (no condensation) Maximum wet bulb temperature shall be 45° C.
Transportation	5% to 95% (no condensation) Maximum wet bulb temperature shall be 45° C.

(table continued on next page)

Table A-8 (cont.)
Environmental Specification

Characteristic	Performance Requirement
Electromagnetic compatibility (EMC)	
Conducted emissions	DIN 57871/VDE 0871/6.78 Class B FCC Part 15 Subpart J Class A
Radiated emissions	DIN 57871/VDE 0871/6.78 Class B FCC Part 15 Subpart J Class A
Electrostatic discharge	Mainframe: 15 kV Adapter Socket: 5 kV
Safety	UL1244 (Pending) (STANDARD FOR ELECTRICAL AND ELEC-TRONIC MEASURING AND TESTING EQUIPMENT) (Not applicable when the 371A is rackkmounted) CSA C22.2 NO.231 (STANDARD FOR ELECTRICAL AND ELECTRONIC MEASURING AND TESTING EQUIPMENT)
Vibration	A 15 minute sweep along each of three major axes at a total displacement of 0.003 in p-p (0.5G at 55 Hz), with frequency varied from 10 Hz to 55 Hz to 10 Hz. Hold 10 minutes at each major resonance, or if no major resonance present, hold 10 minutes at 55 Hz.
Shock (non-operating)	20 G, half sine, 11 ms duration, three shocks per axis in each direction for a total of 18 shocks.
Bench handling	Meets MIL-STD-810C, METHOD 516.2, PROCEDURE V (MIL-T-28800B Section 4.5.5.4.4) with floppy disk drive non-operating and vacant of media.
Packaged transportation drop	Meets the limits of the National Safe Transit Association test procedure 1A-B-2; 10 drops of 24 inches.
Packaged transportation vibration	Meets the limits of the National Safe Transit Association test procedure 1A-B-1; excursion of 1 inch p-p at 4.63 Hz(1.1G) for 60 minutes.

INTERFACE CHARACTERISTICS

Plotter Interface

The plotter interface is based on IEEE 488-1978 (GPIB) standard. The 371A can send VIEW or STORE curve data and CRT readouts with graphic commands (HPGL) to a plotter.

The IEEE 488-1978 (GPIB) standard defines the GPIB interface functions and the allowed subsets of the functions listed in Table A-9.

Table A-9
Plotter Interface Functions

Function	Implemented As
Source handshake	SH1
Acceptor handshake	AH1
Talker	T4
Listener	L0
Service request	SR0
Remote local	RL0
Parallel poll	PP0
Device clear	DC0
Device trigger	DT0
Controller'	C0

GPIB Interface

The IEEE 488-1978 (GPIB) defines the GPIB interface functions and the allowed subsets of the functions listed in Table A-10.

Table A-10
GPIB Interface Functions

Function	Implemented As
Source handshake	SH1
Acceptor handshake	AH1
Talker	T6
Listener	L4
Service request	SR1
Remote Local	RL2
Parallel poll	PP0 (not implemented)
Device clear	DC1
Device trigger	DT0 (not implemented)
Controller'	C0 (not implemented)

Appendix B
DIAGNOSTICS

DIAGNOSTIC CAPABILITIES

The 371A has three sets of diagnostic routines.

- Power-up diagnostics are run every time the 371A is powered up. There is a default set and and an extended set that can be run during power up.

- User-initiated diagnostics can be used to verify the operation of the front-panel controls.

- GPIB controlled diagnostics can be used by a GPIB controller to obtain 371A system ROM and RAM information.

The following provides additional information on each set of diagnostic tests.

POWER-UP DIAGNOSTICS

There are seven power-up tests. Five tests are run automatically each time the 371A is powered up. Two additional (extended) tests can be run by pressing the cursor SHIFT key and then powering up the instrument. These tests are listed in Table B-1 in the sequence they occur during power-up.

Table B-1
Default and Extended Power-up Routines

Diagnostic Test	Routine Default	Sequence Extended
System ROM check	yes	yes
System RAM check	yes	yes
Display RAM Check	yes	yes
Acquisition RAM check	yes	yes
LED check	no	yes
Display quality check	no	yes
Push button test	yes	yes

At power-up, the 371A displays the message SELFTEST START in the message area of the CRT and runs the power-up tests listed in Table B-1. After completing the power-up tests, it displays the message SELFTEST PASS and sets the front-panel settings to their default (initial state).

You can exit the power-up diagnostics by pressing the cursor SHIFT key during power-up.

The following is a description of each power-up test.

Table B-1 (preceding page) lists the ROM and RAM power-up error messages.

System ROM Check

During power-up diagnostics, the ROM is checked by checksum methodology. If a checksum error is found, the error message is displayed in the error message area of the CRT graticule and the 371A does not advance to the next routine. ROM must function properly in order to continue with power-up diagnostics.

The message format is as follows:

```
ROM 000X
```

If a fatal error is found in the system ROM (such as a mis-insertion), the memory location LED blinks 0 and 1 alternately, and the 371A does not advance to the next routine.

System RAM Check

The 371A checks the system RAM with read/write operations. If read/write errors are found, the error message is displayed in the error message area of the CRT graticule and the 371A does not advance to the next routine.

The message format is as follows:

```
RAM XXXXX YYYY
```

If a fatal system RAM error is found (such as a shorted bus), the memory location LED blinks 0 and 2 alternately, and the 371A does not advance to the next routine

Display RAM Check

The 371A checks the display RAM with a read/write operation. If a read/write error is found (such as a shorted bus), the memory location LED blinks 0 and 3 alternately, and the 371A does not advance to the next routine.

Acquisition RAM Check

The 371A checks the acquisition RAM with a read/write operation. If a read/write error is found (such as a shorted bus), the memory location LED blinks 0 and 4 alternately, and the 371A does not advance to the next routine.

Table A-1 lists the Power-up System Error Messages displayed in the memory location LED.

Table B-2
Power-Up System Error Messages

Display	Description
0/1 (blink)	System ROM error (e.g., mis-insertion)
0/2 (blink)	System RAM error (e.g., shorted bus)
0/3 (blink)	Display RAM read/write error (e.g., shorted bus)
0/4 (blink)	Acquisition RAM read/write error (e.g., shorted bus)

LED Check

This is the first of two extended power-up diagnostic routines. This test runs when the operator presses the cursor SHIFT key and holds it pressed when pressing the POWER switch. When the power-up sequence reaches this test, it displays a SONY/Tektronix logo while it sequentially lights all front-panel LEDs.

NOTE

You may have to adjust the NON STORE/STORE/VIEW intensity control to display the SONY/Tektronix logo.

The operator can follow the lighting sequence to obtain a visual indication that the LEDs are operating.

When all LEDs have been lit in sequence, the 371A diagnostic software advances to the display quality check.

> **CAUTION**

Be sure to turn the NON STORE/STORE/VIEW intensity control to a level that prevents burning the CRT when the display quality test pattern is displayed.

Display Quality Check

This is second of two extended power-up diagnostic routines. When the extended power-up sequence reaches this test, the 371A displays a test pattern as shown in Figure B-1. The operator can use this text pattern as a template to align the display vertically and horizontally using the display ROTATION screwdriver adjustments. Use these adjustments to position the display as shown in Figure B-1.

The NON STORE/STORE/VIEW intensity control adjusts the intensity of the bright alignment dots. These dots are displayed at the center, outer corners, and mid-outer lines of the display graticule. The READOUT CURSOR intensity control adjusts the intensity of the double-line, dotted box.
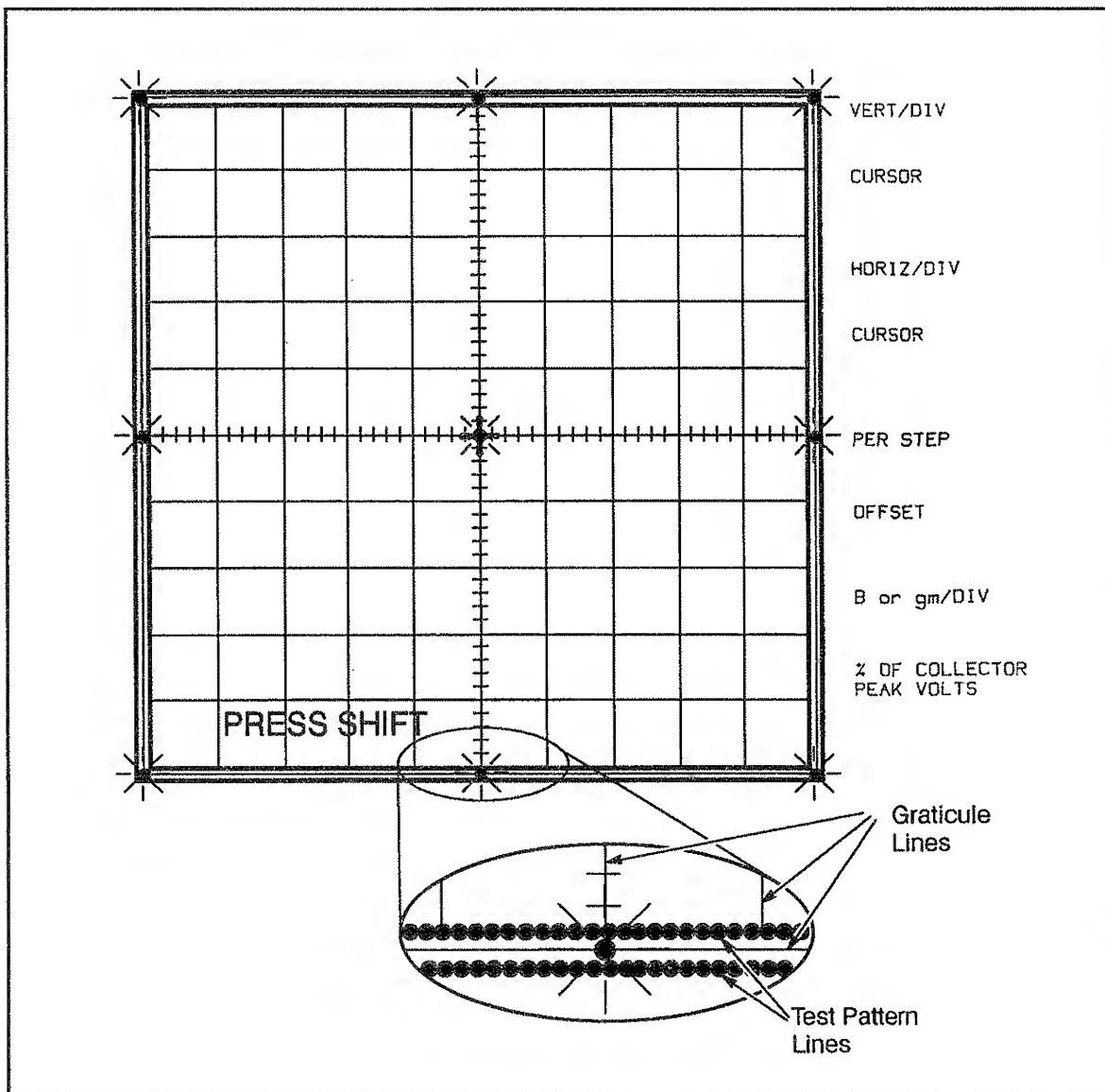
Figure B-1. Display quality test pattern.

Push Button Test

This is the final power-up test for both the default test string and the extended test string. This test includes a push button stack test. It does not check the functionality of the push buttons. If an error is found, the error message is displayed at the bottom of the CRT. The error message is in the following format:

    <STRING> KEY ERROR

where:
<STRING> identifies the front-panel control as listed in Table B-3.

The following message also appears in the text area of the display graticule.

    PUSH SHIFT KEY TO GO ON

The displayed error can be ignored and the test continued by pressing the cursor SHIFT button. However, keep in mind that the front-panel control may not operate correctly.

USER-INITIATED PUSH BUTTON DIAGNOSTIC ROUTINE

This routine displays a number or message that corresponds to the last front panel control used. This routine can be used to determine whether a front-panel control is operating normally.

To start this routine, simultaneously press the cursor SHIFT key, and the NON STORE button. To exit this routine, press the cursor SHIFT key, then press the NON STORE button once again.

Table B-3 lists the 371A controls and the corresponding numbers or messages.

Table B-3
Front Panel Control Identification Messages

Control	Message
Display SAVE	SAVE
Display RECALL	RECALL
Memory location (up arrow)	MEMORY (up arrow)
Memory location (down arrow)	MEMORY (down arrow)
Display NON STORE	NONSTORE
Display STORE	STORE
Display REF	REF
Display VIEW	VIEW
Display ENTER	ENTER
Display INVERT	INVERT
Measurement REPEAT	REPEAT
Measurement SINGLE	SINGLE
Measurement SWEEP	SWEEP
GPIB RESET TO LOCAL	RESET TO LOCAL
GPIB USER REQUEST	USER REQUEST
GPIB PLOT	PLOT
Cursor mode (up arrow)	CURSOR MODE (up arrow)
Cursor mode (down arrow)	CURSOR MODE (down arrow)
Cursor (left arrow)	CURSOR (left arrow)
Cursor (up arrow)	CURSOR (up arrow)
Cursor (right arrow)	CURSOR (right arrow)
Cursor (down arrow)	CURSOR (down arrow)
Cursor SHIFT	SHIFT
Collector supply POLARITY	POLARITY
PEAK POWER WATTS 3 KW	3KW
PEAK POWER WATTS 300 W	300W
PEAK POWER WATTS 30 W	30W
PEAK POWER WATTS 3 W	3W
Step generator INVERT	STEP INVERT
Step generator current source	CURRENT
Step generator voltage source	VOLTAGE
NUMBER OF STEPS (up arrow)	# OF STEPS (up arrow)
NUMBER OF STEPS (down arrow)	# OF STEPS (down arrow)
Step generator OFFSET (up arrow)	OFFSET up (up arrow)
Step generator OFFSET (down arrow)	OFFSET down (down arrow)
Step generator STEP MULTI .1X	STEP MULTI
VERTICAL CURRENT/DIV	VERTICAL XX (XX: 0 - 16)
HORIZONTAL VOLTS/DIV	HORIZONTAL XX (XX: 0 - 16)
STEP/OFFSET AMPLITUDE	STEP AMP XX (XX: 0 - 16)
VARIABLE	VARIABLE XX (XX: 0 - 25)
HIGH CURRENT	H.C. ENABLED: H.C. DISABLED
HIGH VOLTAGE	H.V. ENABLED: H.V. DISABLED
INTERLOCK	INTERLOCK ON: INTERLOCK OFF
GPIB TERMINATOR and ADDRESS	GPIB:XX,term (XX: 0 - 31; term: EOI or LF/EOI)

GPIB DIAGNOSTIC ROUTINE

This routine allows a GPIB controller to obtain system ROM and RAM information over the GPIB.

To initiate this routine, the GPIB controller sends the **TESt?** query over the GPIB. The 371A responds by running its system ROM and RAM diagnostic routines and returning system ROM and RAM information to the controller as follows:

```
TEST ROM:000X, RAM:YYYY
```

Refer to **TESt?** command description in Chapter 5: GPIB for additional information.

Appendix C
MESSAGES

The following is an alphabetical listing of 371A messages that can be displayed in the error message area of the display graticule.

Refer to Table B-2 and Table B-3 in Appendix B: Diagnostics for power-up system error messages and user-initiated push button messages.

CHECKSUM ERROR   Checksum error occurred in the mass storage system COL. RECOVERED is displayed. If the error persists, contact the qualified service person or the nearest Tektronix field service representative.

COL. FUSE BLOW   The collector supply fuse on the rear panel is blown.

COL. OVERHEAT   Series resistor (collector supply) overheat problem. Wait for COL. RECOVERED message. If the error persists, contact the nearest Tektronix field service representative.

COL. RECOVERED   The collector supply is recovered.

COPY CANCELED   Copy mode is canceled.

COPY COMPLETE   Data copying between floppy disk and non-volatile memory is completed.

COPYING CURVES   Characteristic curves are being copied.

COPYING SETUPS   Front-panel setups are being copied.

CPU WAIT ERROR   Internal control hardware errors. If the error persists, contact a qualified service person or the nearest Tektronix field service representative.

DISK FULL   There is no more room to write data on the disk.

ENTER COMPLETE   The displayed curve is saved in the mass storage memory.

ERASE CANCELED   Erasing the non-volatile memory is canceled.

ERASE COMPLETE   The non-volatile memory is erased.

FD DATA EMPTY   Floppy disk has no data in the file specified by the memory location number.

FD NOT READY   The floppy disk drive is not ready or floppy disk is not installed.

FORMAT ABORTED	Disk format is aborted.
FORMAT END	Disk formatting is complete.
FORMAT ERROR FAULT FD READ ERROR FD SEEK ERROR FD WRITE ERROR	Floppy disk system internal error. To determine whether FD the problem is in the floppy disk or in the disk drive, try a new disk. Attempt to save or recall a waveform or a setting. If the disk drive is at fault, contact the nearest Tektronix field service representative. However, you can still use the 371A, although internal floppy disk functions cannot be used.
H.C. DISABLED	HIGH CURRENT breaker is set to the DISABLED position.
H.C. ENABLED	HIGH CURRENT breaker is set to the ENABLED position
H.C. UNMATCH	HIGH CURRENT breaker setting does not conform to saved setting at recall. Set the HIGH CURRENT breaker to conform with the save setting.
INTERLOCK FAIL	Interlock system internal error. Contact the nearest Tektronix field service representative.
H.V/C UNMATCH	HIGH VOLTAGE breaker and HIGH CURRENT breaker setting do not conform to saved setting at recall. Set the HIGH VOLTAGE breaker and HIGH CURRENT breaker to conform to saved setting at recall.
H.V. DISABLED	HIGH VOLTAGE breaker is set to the DISABLED position.
H.V. ENABLED	HIGH VOLTAGE breaker is set to the ENABLED position.
H.V. UNMATCH	HIGH VOLTAGE breaker setting does not conform to saved setting at recall. Set the HIGH VOLTAGE breaker to conform with the saved setting.
INVALID DATA	The data in the file specified by the memory location number is not valid.
NOW FORMATTING	The disk drive is formatting the disk.
NVM DATA EMPTY	Non-volatile memory has no data in the location specified by the memory location number.
NVM R/W ERROR	Non-volatile memory errors. Attempt to save or recall a waveform or a setting. If the error message persists, contact a Tektronix field representative. The 371A can still be used, although internal non-volatile memory functions cannot be used.

OPERATION ERR.   Operation error.

PLL UNLOCK   PLL(phaselocked loop) unlock.

PLOT ABORTED   Plotter output is aborted.

PLOT COMPLETE   Plotter output complete.

PLOT START   Plotter output is started.

SAVE COMPLETE   The current front-panel setting is saved in mass storage.

SELFTEST PASS   The 371A power-up diagnostic tests were successful.

SELFTEST START   The 371A has initiated the power-up diagnostic tests.

S.G. DISABLED   The step generator is disabled. Wait until the message S.G.
                        RECOVERED is displayed. If the error persists, contact the nearest
                        Tektronix field service representative.

S.G. RECOVERED   The step generator is recovered.

SWEEP COMPLETE   The waveform display in the sweep mode is completed.

TEXT CANCELED   Text edit mode is canceled; all text entered is lost.

TEXT EDIT MODE   Text can be entered on the CRT using the cursor position buttons
                        (up, down, left, right).

WRITE PROTECT   The floppy disk is write protected. Set the disk write protect tab
                        to the write enable position.

Appendix D
INSTALLING AND REPACKING

INTRODUCTION

The chapter describes how to perform the initial installation for the 371A and how to pack it for shipment. Information is presented in the following order:

* unpacking and initial inspection

* checking standard accessories

* line voltage requirements

* operating temperature and cooling

* connecting the test fixture unit

* performing power-up and first-time operating procedures

* repacking for shipment

Read all information in this appendix. Perform all installation procedures, and follow all caution and warning notices as documented prior to turning on power.

UNPACKING AND INITIAL INSPECTION

All shipping containers and internal packing material should be saved for reuse. Perform the following to unpack the 371A from its shipping container and to perform initial inspection.

1. Remove the securing bands holding the outer lid on the shipping container.

2. Lift the lid off the shipping container.

3. Remove the accessory box from the carton. Set this box aside to be unpacked later.

| WARNING |

The 371A is heavy. It requires two people to lift the instrument out of its shipping carton. Work carefully to avoid injury due to improper lifting.

The CRT can implode if it or the 371A is handled severely. When handling the 371A always be aware of and practice safe work habits. If damaged, the CRT could implode resulting in serious personal injury.

4. Carefully lift the 371A and the test fixture unit out of the shipping container and place them on a flat, sturdy surface.

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CAUTION
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DO NOT apply power at this time otherwise severe instrument damage may occur.

65 Thoroughly inspect the 371A for mechanical and electrical defects that may have occurred during shipment. If the instrument has been damaged in shipment, first contact the shipping company and then contact your nearest Tektronix field representative.

CHECKING STANDARD ACCESSORIES

Standard accessories are shipped with your 371A. Open the accessories package you removed when unpacking the instrument, and verify its contents against the list of standard accessories provided in Chapter 1: General Information. If there are any discrepancies, contact your nearest Tektronix field representative.

LINE VOLTAGE REQUIREMENTS

This instrument operates from a single-phase power source having a neutral at or near ground (earth) potential. It is not intended for operation from two phases of a multi-phase system, nor across legs of a single-phase, three-wire system. This instrument can be operated from either a 100 V, 120 V, 200 V, or 240 V nominal supply source of 48 to 63 Hz. Table D-1 provides a listing of line voltage ranges, line frequency range, and power consumption.The line voltage setting of the instrument is indicated by a screw on the rear panel (shown in Figure D-1).

Table D-1
Line Voltage Ranges

Line Voltage		Fuses	
Nominal	Range	Main	Collector
240 V	216 V - 250 V	250 V, 1 A, slow blow	250 V, 2 A, slow blow
200 V	180 V - 220 V		
120 V	108 V - 132 V	250 V, 2 A, slow blow	250 V, 4 A, slow blow
100 V	90 V - 110 V		
Line Frequency	48 - 63 Hz		
Maximum Power	400 W, 4.5 A		
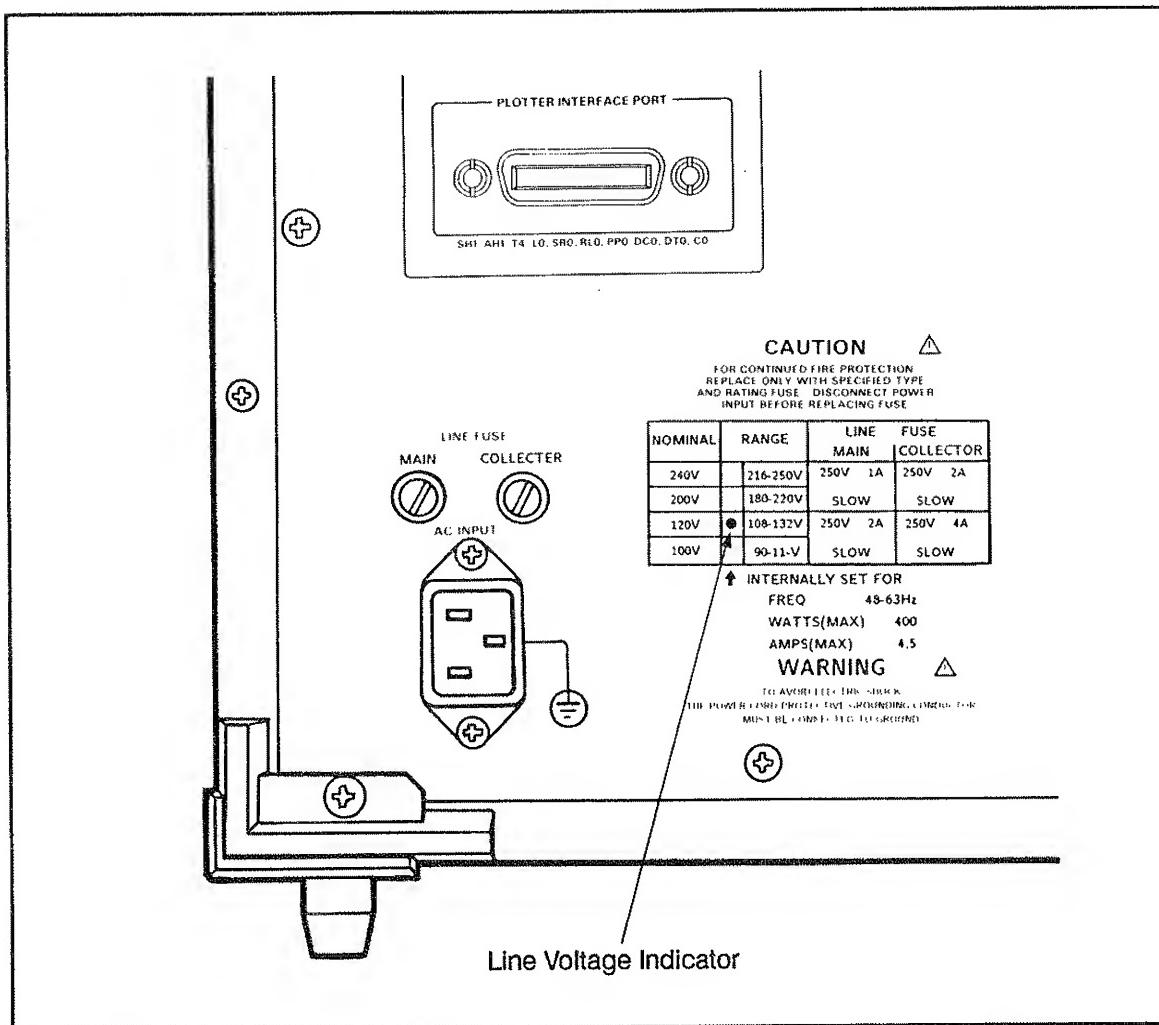
Figure D-1. Location of the LINE VOLTAGE INDICATOR.

CAUTION

To prevent damage to the instrument, check the position of the LINE VOLTAGE INDICATOR located on the rear panel of the 371A before connecting the instrument to a line voltage source. Also, check to ensure that the proper line fuses are installed for the main and collector power supplies.

If the LINE VOLTAGE INDICATOR indicates that the 371A is configured to operate at a voltage other than that available at the user's site, contact your local Tektronix field representative, or refer a qualified service technician to "Line Voltage Wiring" in Chapter 3: Maintenance of the 371A Service manual.

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┌─────────────────┐
│     WARNING     │
└─────────────────┘
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*This instrument operates from a single-phase power source, and has a
detachable three-wire power cord with a two-pole, three-terminal grounding
plug. The voltage to ground (earth) from either pole of the power source must
not exceed the maximum rated operating voltage (250 rms).*

*Before making connection to the power source, make sure that the
instrument is set for the power source voltage, and is equipped with a
suitable plug (two-pole, three-terminal, with ground).*

*This instrument is IEC Safety Class 1 equipment. All accessible
conductive parts are directly connected through the grounding conductor of
the power cord to the grounding contact of the power plug. Therefore, the
power plug must only be inserted in a mating receptacle with a grounding
contact. Do not defeat the grounding connection. Any interruption of the
grounding connection can create an electric shock hazard.*

Refer to Table 1-1 in Chapter 1: General Information if a power cord other than the one
supplied is required.

OPERATING TEMPERATURE AND COOLING

The 371A can be operated where the ambient temperature is between +10° C and +40° C.
After storage at temperatures outside the operating limits, allow the chassis temperature to
reach the safe operating limits before applying power.

The instrument is cooled by air drawn in through the air filter on the rear panel and blown
out through holes in the side panels. For proper instrument cooling, provide adequate
clearance of at least two inches on the rear and sides to ensure free air flow and dissipation
of heat away from the unit.

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┌─────────────────┐
│     CAUTION     │
└─────────────────┘
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*Prolonged use of the 371A can cause high temperatures which may damage
the instrument or DUT. When applying current in the 3 kW range of the
peak power watts selector, test time should be limited to four minutes,
followed by at least 11 minutes of cooling.*

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┌─────────────────┐
│     WARNING     │
└─────────────────┘
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*Prolonged use of the 371A at high power settings can make the device under
test, test fixture unit, or protective cover hot enough to cause injury. Avoid
touching any of these areas until cooled.*

CONNECTING THE TEST FIXTURE UNIT

Before powering-up the 371A, connect it to the test fixture unit as shown in Figure D-2. (Device measurements are performed using the test fixture with its adapter panel, patch panel, and patch cords.
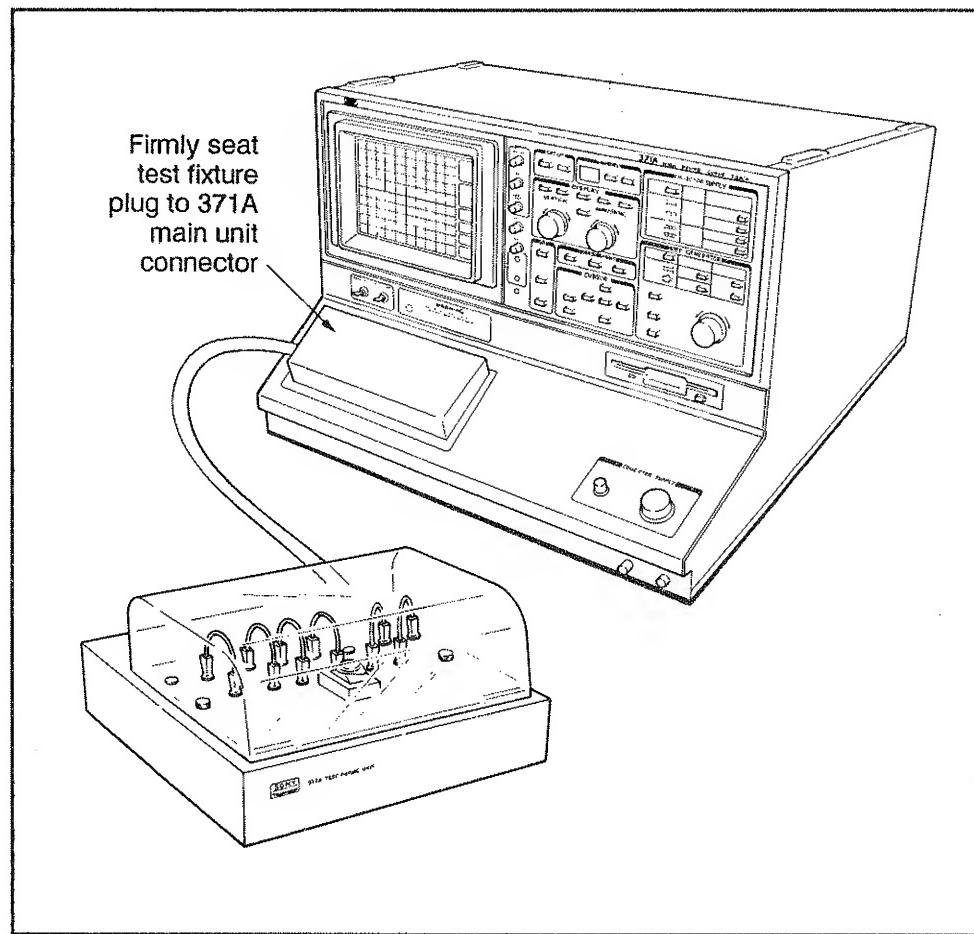
Figure D-2. Connecting the test fixture unit to the 371A.

CAUTION

When inserting the test fixture unit plug into its connector on the 371A, be certain the plug is parallel to the connector surface so that the connecting pins will be inserted straight into the connector; otherwise the connector and its pins could be damaged.

Test Fixture Interlock

The 371A main unit/test fixture system is provided with a safety interlock system that disables the collector supply at the patch panel terminals on the test fixture unit. Whenever the patch panel cover is in the raised position, the collector supply voltage is disabled and you can safely connect/disconnect devices at the patch panel. When the safety cover is closed, the collector supply voltage is enabled. The enabled state is indicated by a red WARNING indicator on the 371A. When lit, the WARNING indicator cautions the user that the collector supply is enabled and that a dangerous voltage may appear at the patch panel terminals on the test fixture unit.

The collector supply is also disabled whenever the test fixture unit cable is disconnected from its connector at the front panel of the main unit.

PERFORMING POWER-UP AND FIRST-TIME OPERATING EXERCISES

After you have ensured that the 371A is connected to the appropriate line voltage and the test fixture unit is properly connected to the main unit, you are ready to power-up the instrument and verify its operation. Refer to the following information located elsewhere in this manual.

- "Device Connection" in Chapter 2: General Information
- "First Time Operating Exercises" in Chapter 3: Exercises.
- "Measurement Exercises" in Chapter 3: Exercises.

The information you need and the sequence in which you need to read it, depends on your familiarity with curve tracer instruments. Refer to "Recommend Learning Path" in in the Preface for a recommended learning path.

For a complete verification of electrical performance, refer a qualified service technician to the "Performance Check and Adjustment Procedures" in Chapter 4: Performance Check and Adjustment of the *371A Service* manual. The 371A should meet all performance characteristics listed in Appendix A: Specifications. If a discrepancy is found, contact your local Tektronix field representative or refer a qualified service technician to the "Performance Check and Adjustment Procedures" in Chapter 4: Performance Check and Adjustment of the *371A Service* manual.

REPACKING FOR SHIPMENT

If you must ship the 371A long distances, we recommend that you repackage the instrument the same as when it initially arrived are your site. The cartons and packaging material in which the instrument was shipped should be saved and used for this purpose.

If the instrument is shipped to a Tektronix service center for service or repair, attach a tag to the instrument showing the following information:

• owner of the instrument (with address)

• name of a person at your firm to contact

• instrument type and instrument serial number

• description of the service requested

If the original packaging is unfit for use or not available, package the instrument as follows:

1. Obtain a corrugated cardboard shipping carton with a 375 lb test strength and inside dimensions at least six inches greater than the instrument dimensions.

2. Surround the instrument with polyethylene sheeting to protect the finish.

3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, placing at least three inches of dunnage on all sides.

4. Seal the carton with shipping tape or with an industrial stapler.

5. Write the address of the Tektronix service center and your return address on the carton in one or more prominent locations.

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